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CENTRAL ASIA AND TIBET.*

DR. SVEN HEDIN is without doubt the most remarkable explorer now living. From an early age he adopted exploration as a profession, and Asia as a speciality. His training to this end has made him able to perform single-handed most extensive journeys into unknown parts of Central Asia, which have yielded splendid scientific results. His organising powers are great. As a topographer he has no rival, while he is also able to undertake successfully the work of a meteorologist, geologist, biologist, ethnologist, archæologist, and many other specialities, and thus is empowered to give an accurate picture of the country through which he travels.

The scientific results of his latest expedition have still to be worked out, and their publication in detailed form is, we are glad to say, assured. In the present volumes we have only the narrative of his travels, with an inkling of what is to come in the way of valuable scientific results.

It is possible in the limits of this notice to give only a general idea of Dr. Hedin's journeyings. From the middle of 1899 to the middle of 1902 he was travelling almost incessantly, his various routes in Asia extending to a total of some 6000 miles. The narrative of these journeys, contained in these two fine volumes of over 600 pages each, is in the form of an orderly journal, solid with fact and detail, but at the same time vividly written, so that one's interest in the chronicles of each day's doings is held to the end. The narrative, in fact, not only gives a lifelike picture of the country through which the explorer passed, and of how he got through it, but reveals besides many a deep insight into Asiatic character, while of his own character the author unconsciously draws a most interesting picture—great determination and dogged pluck, with now and again a suspicion of rashness, untiring energy, a keen foresight, cheerfulness under all circumstances, a singular humane and sympathetic nature, are among the characteristics displayed.

In August, 1899, Dr. Hedin reached Kashgar, in Turkestan. Equipping there a carefully-organized caravan, he proceeded to the Yarkand Daria, or Tarim, the great river which flows through the deserts of Eastern Turkestan. Here at Lailik began the first and perhaps most important part of his journeys. Converting with immense labour and great ingenuity a ferry boat into a floating residence and observatory, he committed himself to the broad waters of the lonely Tarim. The greater part of the first volume of the narrative is occupied by an account of this almost idyllic journey. But it was a journey of great geographical importance for the hitherto little known and badly-mapped Tarim is now, by the labours of Dr. Hedin, the best-mapped river out of Europe.

For months, day after day, as the boat floated down the great river, the author sat glued to his table, mapping on a large scale every twist and turn of the stream, checking and rechecking his measurements, frequently measuring the depth and width of the river, and the velocity and volume of its waters. As long as the boat was moving there was no time for relaxation. "I was never able to quit my post for an instant to stretch my legs. We hardly ever travelled more than ten minutes in a straight line. . . . . Hence I had to keep my eyes upon the compass." But if the work was hard, and perhaps many would think monotonous, Dr. Hedin was enchanted by this voyage. The scenery in parts was beautiful. "The forest stretched right down to the very brink of the river. . . . . High up on the sky-line ran the green coping of the poplars' crowns, making a dense curtain of foliage which seldom allowed a glimpse of the tree-trunks to gleam between—green, but green shot with various shades of rich brown, so rich that they would have been harsh had their effect not been softened by the hazy sky behind them." But at other times the country through which the river ran was utterly barren, the soil being sand. And as the Great Takla Makan Desert was reached "we were engulfed in that awful Asiatic silence—a silence as of the dead. No greeting came to meet us from the heart of the desert. The river—the river alone—sang its rippling song to the irresponsive sand. . . . . Very strange to be crossing one of the earth's greatest deserts

* "Central Asia and Tibet. Towards the Holy City of Lassa." By Sven Hedin. (Hurst & Blackett.) 2 vols. Illustrated. £2 2s. net.

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by water! Not so very long ago I had nearly died there for want of it."

And not only did the scenery change as they drifted on, but the fiery heats of summer were succeeded by the violent autumn storms, and then the winter crept steadily and remorselessly on. The surface of the river one morning was spangled with patches of ice. Then a fringe of ice crept out day after day further from the banks, and the air was full of murmurs from the grinding ice, but there was still time to go many miles before the passage was blocked completely by the ice. Then winter quarters were formed, and the caravan, which had made the long journey by land, was successfully joined. "Never," writes Dr. Hedin, "was a journey of that magnitude carried through so comfortably and so successfully." And we believe him, for with little danger and with no great difficulty for so resourceful and intrepid an explorer, a thousand miles of a practically unknown river was most minutely investigated in the space of some three months.

Dr. Hedin is not one to rest on his oars. No sooner had he got his winter quarters comfortably arranged than he started out on a perilous journey southwards across the Takla Makan Desert to Cherchen, situated on the river of that name. This desert journey in the middle of a very hard winter, with temperatures of many degrees below zero, and frequent blinding snow-storms, was a very trying piece of work, but it was accomplished with the loss of only one camel.

After an excursion to the south-west from Cherchen, which involved a very cold ride of 200 miles, Dr. Hedin brought his caravan back to his winter quarters, travelling for the most part by the ancient bed of the Cherchen River. Meanwhile his head-quarters camp had become "an important market, well known throughout all the Lop country, and immediately outside its precincts there grew up a ring of small 'suburbs,' where tailors, smiths, and other handicraftsmen came and plied their several trades." And Dr. Hedin became quite a king in the Lop country, and was able to set right many injustices to the poor.

In the springs of 1900 and 1901, Dr. Hedin turned his attention to the district of the famous Lop-nor and its sister lakes. His work here was very important and interesting. The Tarim empties itself into the great depression of the Lop Desert. It has been long suspected that the lake into which this great river discharges its waters has shifted from time to time. Dr. Hedin has amply proved this to be the fact, by an examination of the Kara-Koshun Lakes, into which the river now empties itself, and by a careful survey and levelling of that part of the desert in which the old lake was suspected to have existed. Moreover, he found that the present lake was actually travelling back to its old bed. "Nor is it surprising," he writes, "that such should be the case in this desert, which my survey proved to be almost perfectly horizontal. While the Lake of Kara-Koshun, which had existed a long time in its southern half, was being filled up with mud, drift-sand, and decaying vegetation, the arid northern half was being excavated and blown away by the winds, and thus being hollowed out to a deeper level. Now these changes of niveau are determined by purely mechanical laws and local atmospheric conditions; consequently the lake which serves as the terminal reservoir of the Tarim system, must be extremely sensitive to their influence. . . . Then vegetation and animal life, as well as the fishing population, inevitably accompany the water as it migrates, and the old lake-bed dries up." In connection with this last observation, Dr. Hedin made a most important historical discovery. In the spring of 1900 one of his men found by a lucky chance, in the middle of the desert, some old ruins. The next spring these were searched for and rediscovered. The material obtained from them has not yet been fully worked out, but enough has been done to show that this spot, on the shores of the ancient Lop-nor, was the site of Lôu-lan, an important country in olden times, since it was situated between the great northern highway and the great southern highway from China to Europe. Long known historically to the Chinese, its position hitherto has never been accurately fixed. "How different, how exceedingly different this region was now compared with what it must have been formerly! Here was now not a single fallen leaf; not a single desert spider. . . . There was only one power which brought sound and movement into these dreary, lifeless wastes, namely, the wind. . . . I can imagine how beautiful a spot it was—the temple . . . . embowerered amid the shady poplar groves, with an arm of the lake touching it. . . . Round about it were the scattered villages. . . . Southwards stretched far and wide the bluish-green waters of Lop-nor, set about with forest groves. . . . Look upon that picture and then look upon the picture of the scene as it is now! An endless array of cenotaphs! And why is this? It is simply because a river, the Tarim, has changed its course." For an account of the many difficulties, hardships, and dangers that the explorer and his party experienced in the exploration of this great desert and the surrounding country, we must refer our readers to the traveller's own modest but graphic account.

Dr. Hedin's next and last great journey was an exceedingly long and trying one across the northern part of Tibet. For this journey he organised an immense caravan of camels, horses, and asses, but so difficult was the country, and so great were the hardships, chiefly on account of most of the time being spent at great altitudes, that very few of these animals survived, while several men died from the same cause. Dr. Hedin is not one to make much of hardships and difficulties, and his statement with regard to this journey is therefore significant. "For my part," he writes, "I would rather cross the Desert of Gobi a dozen times than travel through Tibet once again in winter. It is impossible to form any conception of what it is like; it is a veritable *via dolorosa!*" And we might add that there would have been little chance of any less hardy or experienced traveller getting through at all. During this journey Dr. Hedin made a plucky dash towards Lassa in the disguise of a Mongol pilgrim. But the Dalai Lama had got wind of his big caravan far away in the mountains, and he was stopped very firmly, but certainly not unkindly, on the threshold almost of his goal, and eventually escorted back to his caravan. After this the Tibetans continually escorted the caravan, keeping a small army on its flank, and effectually preventing the explorer from going to the south. In view of our present advance into Southern Tibet, it is of interest to note that Dr. Hedin considers that the Tibetan's "policy of isolation during the last half century or so has not been dictated by religious, but by political motives. Their tactics, peaceful, but so far successful, have aimed at guarding their frontiers against Europeans." None but Europeans are tabooed. "Still Tibet will have to meet her destiny," says the author, and the day now seems near at hand.

As to the narrative in general, we may say that it is a most engrossing account of a very remarkable series of explorations. The book is well produced in every way. It has most excellent maps, and the illustrations from the author's photographs (over which he took the greatest possible pains) and sketches are exceptionally good.—H. F. W.

FUNGI AS LINKS IN THE CHAIN OF LIFE.

I.—THE NATURE, HABITATS, AND DISTRIBUTION OF FUNGI.

By G. MASSEE.

FUNGI include the mushrooms and toadstools, as well as moulds, mildews, truffles, puff-balls and yeasts, and number altogether between fifty and sixty thousand different kinds.

It is only by comparing their mode of life with that of other groups of plants that the true nature of fungi and their special characteristics can be clearly understood. Flowering plants, ferns, mosses, seaweeds and lichens, in fact all plants with the exception of fungi, possess chlorophyll; owing to the action of which they are enabled to use carbonic acid and other inorganic substances as food. Now the absence of chlorophyll must be considered as the most distinctive hall-mark of the fungi, and its absence implies their inability to utilize inorganic substances as food. This feature places fungi on a par with animals, inasmuch as both agree in requiring organic food. This fact is obvious in the case of those fungi that develop as parasites on living plants, as the destructive rusts and mildews on wheat, barley, and numerous other plants, both wild and cultivated. Neither would anyone doubt the statement in the case of fungi growing on, and consequently obtaining their food from rotten wood or dead leaves. The case is not at first sight so evident, where fungi, as the common mushroom, spring directly from the ground; when it might be supposed that the fungus obtained its food from the same source as the grass growing around it.

Careful examination, however, would reveal the fact that the spawn of the mushroom derived its food from the decaying portions of grass and humus present, and not from the soil. It will be remembered that when mushrooms are cultivated artificially, the spawn is placed in manure, which is organic matter, although dead and more or less decomposed, and is not to be compared to such inorganic substances as carbonic acid, obtained from the air, and certain salts derived from the soil, which furnish the grass with its food.

Now this condition of things naturally prevents the fungi from being pioneers in the dispersal of plant-life over the globe. Mosses, algæ, and other simple forms of chlorophyll-bearing plants, requiring only moisture, air, and soluble rock constituents as food, can manage to grow in barren and hitherto lifeless regions, if their seeds happen to be carried by wind or other agents. This is not so with fungi, which, for the reasons already stated, require organic food.

There are no other fast lines between fungi and other members of the Vegetable Kingdom, all other distinctions being only differences of degree. Taking structure, we find that the characteristic unit, a cell with a well-defined wall or enclosing membrane, forms the groundwork of fungi, exactly as in all other plants, only in fungi the component cells are not differentiated into what are known as vessels, cork-cells, bast, &c., as in the higher plants. The reason for this absence of specialized structure in the fungi is the comparative absence of division of labour in these plants as compared with ferns and flowering plants.

To understand this point of difference it must be remembered that in all except the very simplest of plants, which often consist of a single microscopic cell, there is a well-marked division into a vegetative and a reproductive stage; and even in the simple one-celled plants alluded to above, the one cell constituting the individual spends the first period of its existence as a vegetative, and the last part as a reproductive body.

By the vegetative portion is meant all structures and work done for the welfare of the individual; whereas the reproductive phase is entirely for the purpose of producing other individuals of the same kind, usually from seeds.

Now if we take an oak tree as an example of one of the chlorophyll-bearing plants, the root, trunk, branches and leaves, in fact every part except the flowers and fruit, belong to the vegetative stage, in other words all the parts mentioned are necessary for the continuance of life in the individual tree under consideration. As the oak lives for many years, the division of labour, or different kinds of work necessary to enable it to do so, are many and varied. Of primary importance is a special arrangement for obtaining food from the air and the soil, converting the same finally into parts of the tree, and enabling the food to spread to every growing portion of the plant. Then, again, certain portions of the structure are told off for the purpose of giving strength to the whole fabric, so that the tree can withstand the force of the elements.

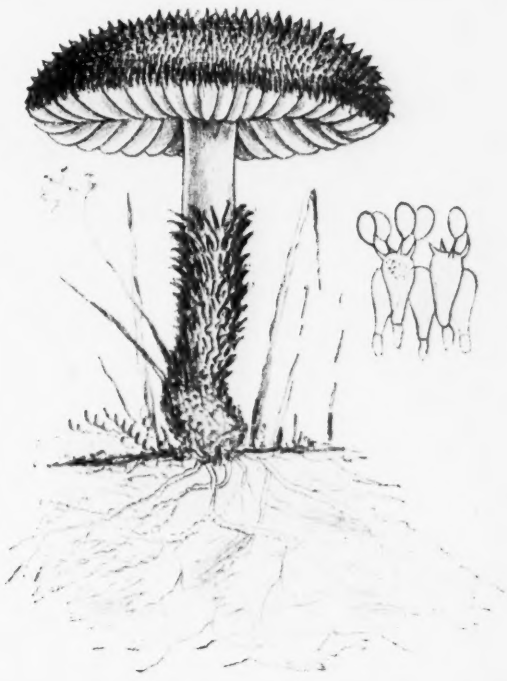

FIG. 1.—A typical Agaric or gill-bearing fungus (*Agaricus hystrix*). The part above the ground-line is the reproductive portion; the part below is the vegetative portion. Natural size. The figure on the right shows two basidia bearing four spores each. Magnified 500 times.

As there is a limit to the life of the oak tree, in common with every other living organism, some provision is necessary for the continuance of the same kind of tree in the future. This necessity is provided for by the production of flowers; these in the case of the oak eventually give origin to acorns, or seed, which in due course develop into other oak trees. This represents the reproductive cycle of the oak tree, and it will be remarked that, so far as volume

is concerned, it is very small compared to the permanent vegetative portion of the tree.

Now, as a rule, in fungi the above proportions of the vegetative and reproductive portions of the plant are reversed as compared with the oak tree; in other words, the reproductive portion of a fungus is much larger, and also more conspicuous than the vegetative portion.

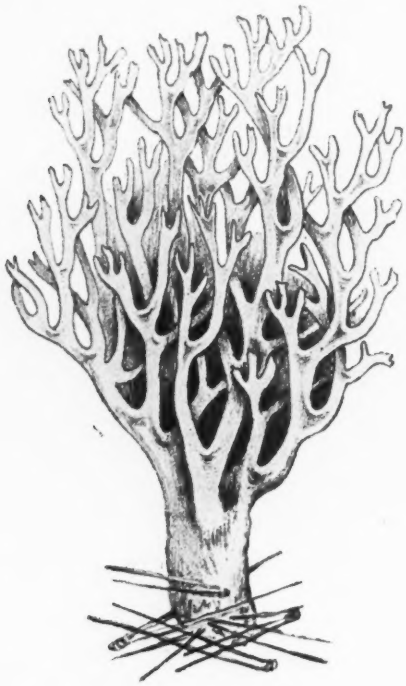

FIG. 2.—A second type of Basidiomycetes (*Clavaria abiëtina*). The entire branched portion is covered with basidia bearing spores. Common in our pine woods. Natural size.

If we take as an illustration the common mushroom, the aspect of which is familiar to most people, then what is presumably considered to represent the whole plant—namely, the stem, cap, and gills—only in reality represents the reproductive portion of the fungus, being, in fact, the exact equivalent in function of the flowers in the oak; the equivalents of seeds, called *spores* in the fungi, being produced on the surface of the gills. On the other hand, the vegetative portion of the mushroom consists of the comparatively small portion of white thread-like spawn or *mycelium* ramifying in the manure or other substance on which the fungus is growing.

The same arrangement of parts is practically true for all other fungi; the portion visible to the naked eye, however varied its form or colour, represents only the reproductive portion; whereas the vegetative part is buried in the substance from which the fungus obtains its food.

The popular belief that the mushroom and other fungi grow in a single night is not correct; it is quite true that when the mushroom has reached a certain stage of development, one or two days suffices for it to attain its full size after it appears above ground. Before this final spurt is reached, however, the baby mushroom has been growing for some weeks, and undergone various changes of structure and development before it emerges above ground. A little thought will recall to mind the fact that mushrooms do not spring up within two or three days after the formation of a mushroom bed, but several weeks elapse before the mushrooms are ready for the table.

As to the origin of the fungi, the opinion held at the present day is that they originated or evolved from the algæ or seaweeds, or their freshwater representatives.

The most primitive groups of fungi are aquatic in habitat, and closely resemble in structure certain algæ; in fact, at the beginning of the fungal group a fungus was an alga devoid of chlorophyll, the parasitic habit adopted by the pioneers of the fungi enabling them to dispense with this green substance. The sequence of evolution from these primitive types of fungi to the most modern members of the group—the agarics or gill-bearing fungi, and the puffballs—is fairly complete, and in evidence at the present day.

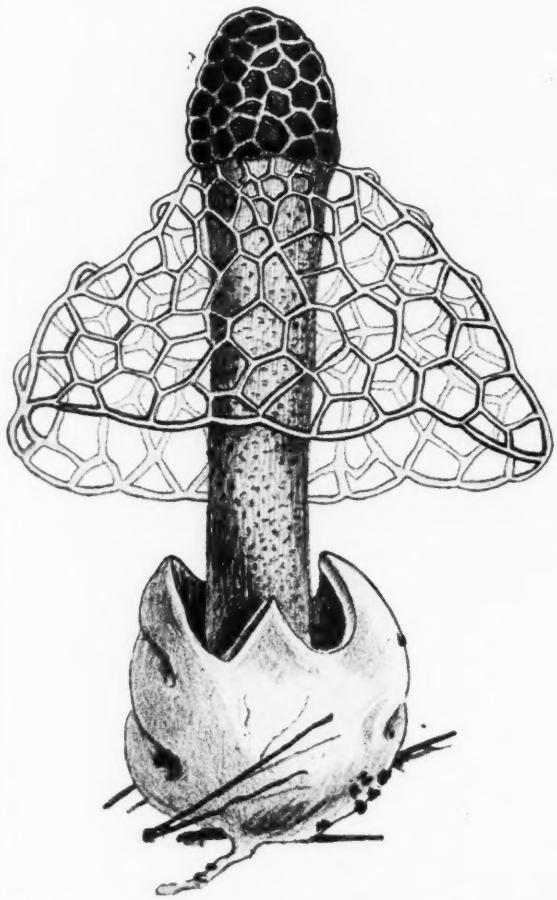

FIG. 3.—A third type of the Basidiomycetes (*Dictyophora phalloidea*). The entire upper portion is enclosed in the hollow covering or volva, until the spores are mature, when the stem elongates and bursts through the volva, and the crinoline-like network expands to form a landing-stage for insects, who devour the slime containing the spores, which is produced on the dark upper portion of the stem. Natural size. Not uncommon in Brazilian and other tropical forests.

On the other hand, had the agarics and puffballs only been met with at present, the true origin of the group would never have been suspected, so completely have all traces of primordial structure and affinity been effaced,

combined with a complete loss of all trace of sexual reproduction.

The many causes combined to effect this remarkable change cannot be discussed here; suffice it to say that the transition from an aquatic to a terrestrial habitat is a main factor.

The fungi are primarily divided into two groups, depending on the mode of origin of the spores or reproductive bodies. In the first or older group, dating from their secession from the algæ, the spores are produced inside special cells called *asci*, and the spores are technically described as *ascospores*. In the older representatives of this group, that is those nearest to the algæ, there is a distinct mode of sexual reproduction, in many instances indistinguishable from that presented by many algæ, but as the members invaded dry land the sexual mode of reproduction gradually disappeared, and is now comparatively rare; nevertheless the same general form of spore-producing structure is maintained.

Now as these fungi became more and more accustomed to existence on dry land, a most important addition to their means of reproduction gradually evolved. This consisted in the development of secondary kinds of reproductive bodies, technically called *conidia*. Now conidia more or less resemble ordinary spores in structure and appearance, but differ in not being a sexual product.

This group of fungi, collectively known as the Ascomycetes, includes many thousands of different kinds, large numbers of which are very minute, and known only to those specially interested in the study of the fungi.

Among kinds belonging to this group, and fairly well known, may be enumerated the Morels, Truffles, Yeasts, and certain of the minute forms popularly known as moulds and mildews.

The second large group, called the Basidiomycetes, have the spores borne on the surface of special cells called *basidia*, hence the spores are spoken of as *basidiospores*. In this group there is no vestige left of the sexual mode of reproduction. The representatives of this section are usually much larger in size than those of the Ascomycetes, and include such well-known forms as the common mushroom, toadstools, puffballs, and the woody, bracket-shaped or hoof-shaped fungi growing on trees. It has already been stated that secondary forms of fruit are produced by fungi, but it is necessary to enter more into detail respecting this matter, as the extremes to which this idea is carried out in certain groups has no parallel elsewhere in the vegetable kingdom.

In some fungi the different stages which together form the complete cycle of development are as different in general appearance and relative size as that between a poppy and an ash tree. Not only is this the case but the various forms usually grow at different periods of the year, one may be an annual and the other a perennial condition; and, finally, when parasites, the forms may grow on different kinds of host-plants.

As an instance of such multiplicity of forms representing phases in the life-cycle of an individual, may be mentioned the common and very destructive wheat rust. The spring stage of this fungus appears under the form of clusters of miniature cups with fringed edges, filled with orange spores, on living leaves of the barberry. The spores of this form are scattered by wind, and those that happen to alight on a blade of wheat soon germinate and enter the tissues, and in course of time produce minute streaks of a rust colour on the surface of the living leaf. The spores of this second condition, dispersed by wind, inoculate other wheat plants, and as the spores are produced in rapid succession throughout the summer, it can be readily understood how quickly an epidemic of disease can spread after a parasitic fungus has once secured an entrance. Towards the autumn, a third form of fruit is produced on the fading wheat leaves, quite different in appearance from either of the two stages previously mentioned. The spores of this third stage are called *resting spores*, because they remain unchanged until the following spring, when they germinate and inoculate young barberry leaves, which results in the production of the first stage of the fungus again, and the cycle of development proceeds as before.

Some fungi have two distinct forms in the life-cycle; some three, as wheat rust; some four or even more. In some instances, one form of the cycle can be omitted at times, as in the case of wheat rust, where the stage on barberry is dropped altogether in some countries.

Thousands of different fungi have the individual made up as it were of a number of distinct, different looking

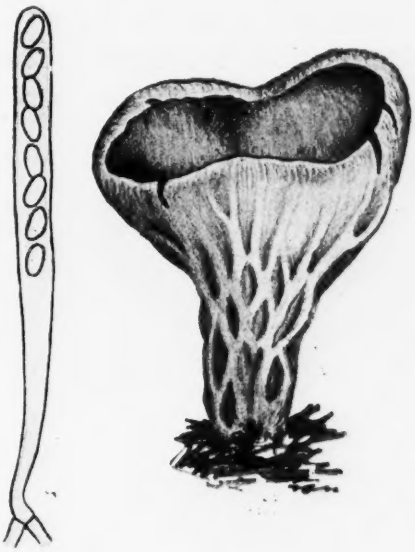

FIG. 4.—An example of the Ascomycetes *(Peziza acetabulum)*. The asci line the inside of the cup. Natural size. On the left is an ascus containing eight spores. Magnified 500 times. Not uncommon on the ground in our woods.

parts growing at different periods of the year under different conditions, and fulfilling varied functions in the life of the complete plant. The use of the quickly-growing summer condition is to furnish an enormous number of spores, by which the fungus is enabled to extend its geographical distribution; whereas the autumn form, producing resting spores, is for the purpose of preserving the species in time, by bridging over the period when the plant on which the fungus is parasitic is not growing.

The various methods of spore dispersion as occurring in the fungi are interesting; only a few of the most pronounced can be noticed here. By far the most universal agent in effecting the distribution of spores is wind, as may be observed when a ripe puffball is crushed under foot. Insects are also answerable for the extension of many fungus epidemics, by alternately feeding on, or visiting diseased and healthy plants, and in so doing unconsciously conveying spores from one plant to another. Perhaps the most interesting instance occurs in a group of fungi to which our "stinkhorn" belongs. Most of the species are tropical, in this country we have only three representatives. In this group the reproductive portion

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of the fungus often assumes most fantastic forms, and is generally brilliantly coloured. Over this framework is spread at maturity a dingy green, semi-fluid mass, intensely sweet to the taste, and, from the ordinary human standpoint, intensely fœtid; the exceedingly minute spores are imbedded in this substance, which is greedily devoured by various kinds of insects, mostly flies, who thus unconsciously diffuse the spores, as it has been shown that these are not injured by passing through the alimentary tract of an insect. It is interesting to note that in certain of the fungi the same advertisements in the guise of colour, sweet taste and smell, are used for the purpose of unconscious dispersion of the spores by insects, as are used by many flowering plants for the purpose of securing cross-fertilization, also through the agency of insects.

MODERN COSMOGONIES.*

VI.—WORLD-BUILDING OUT OF METEORITES.

By AGNES M. CLERKE.

THE idea is seductive that we see in every meteoric fire-streak a remnant of the process by which our world, and other worlds like or unlike it, were formed. It is not a new idea. Chladni entertained it in 1794; and it has since from time to time been revived and rehabilitated with the aid of improved theoretical knowledge and a larger array of facts. Survivals are tempting to thought. It costs less effort to realise differences in degree than differences of kind. The enhanced activity of familiar operations is readily imagined; while perplexity is apt to shroud the results of modes of working strange to experience. Hence the presumption in favour of continuity; nor can it be said, even apart from our own mental inadequacy, that the presumption is other than legitimate. Nature is chary of her plans, lavish of her materials. Her aims are characterized by a majestic unity, but she takes little account (that we can see) of surplusage or wreckage. Now it seems likely that meteorites represent one or the other of these two forms of waste stuff. They are analogous, apparently, either to the chips from shaped blocks, or to the dust and rubbish of their destruction. Let us consider what it is that we actually know about them.

It cannot be said that the sources of our information are scanty. Fully one hundred millions are daily appropriated by the earth as she peacefully pursues her way. Their absorption leaves her unaffected. It produces no perceptible change in her internal economy, and makes no sensible addition to her mass. The hundred millions of small bodies taken up have, nevertheless, in Professor Langley's opinion, an aggregate weight of more than one hundred tons.† And this increment is always going on. Yet its accumulated effect is evanescent by comparison with the enormous mass of our globe. That it was more considerable in past ages than it is at present, might be plausibly conjectured, but cannot reasonably be maintained. Geological deposits contain—unless by some rare exception—no recognizable meteoric ingredients. There is nothing to show that the earth was subject to a heavier bombardment from space during the Silurian era than in the twentieth century.

Meteorites signify their existence to us, in general, only by the bale-fires of their ruin; but in a few cases its actual relics come to hand. Those substantial enough to escape total disintegration through atmospheric resistance to their swift movements find their way to museums and laboratories, where they are subjected to the searching investigation demanded by their exotic origin. Its results are scarcely what might have been expected. Meteorites are not peculiar chemically; they consist exclusively of the same elementary substances composing the crust of the earth; but their mineralogy is highly distinctive. They are extremely complex structures, formed, apparently, in the absence of water, and with a short supply of oxygen; the further condition of powerful pressure is indicated with some probability, nay, with virtual certainty for those including small diamonds;* while prolonged vicissitudes of fracture and re-agglomeration are possibly recorded by the brecciated texture of many of these rocky *trouvailles*. Their aspect is thus anything but primitive; each fragment tacitly lays claim to an eventful history; they suggest a cataclysm, of which we behold in them the shattered outcome. The nature of such cataclysms is scarcely open to conjecture; only a hint regarding it may be gathered from the circumstance that the most profound terrestrial formations are those which approximate most closely to the mineralogical characteristics of meteorites.

Nevertheless, their only ascertained relationships are with comets. In every system of shooting stars the primary body most probably is, or at any rate was, a comet. Each appears to be the offspring of a cometary parent, and develops in the proportion of its decay. The view has hence been adopted, and not without justification, that comets in their primitive integrity are simply "meteor-swarms." Assent may be given to it with some qualifications which we need not here stop to discuss. What immediately concerns us is the interesting question as to the constitution of meteor-swarms. What is the real meaning of the term? What does it convey to our minds? A meteor-swarm may be defined as a rudely globular aggregation of small cosmical masses, revolving, under the influence of their mutual attraction, round their common centre of gravity. Each must revolve on its own account, though all have the same period; and their orbits may be inclined at all possible angles to a given plane, and may be traversed indifferently in either direction. From this tumultuous mode of circulation collisions should frequently ensue; but they would be of a mild character. They could not be otherwise in a system of insignificant mass, and correspondingly sluggish motion. We are considering, it must be remembered, only cometary swarms, as being the only collections of the sort that come, even remotely, within our ken; and comets include the minimum of matter. None of those hitherto observed, at least, whether conspicuous or obscure, newly arrived from space, or obviously effete, have occasioned the slightest gravitational disturbance to any member of our system.

Eventually, a cometary swarm, if left to itself, would probably take something of a Saturnian shape. Colliding particles would, owing to their loss of velocity, subside towards the centre, and accrete into a globular mass. A predominant current of movement would, through their elimination, gain more and more completely the upper hand; and it would finally, with the inevitable diminution of energy,† be restricted almost wholly to the principal

* For former articles under this title *see* KNOWLEDGE, 1903, pp. 57, 104, 148, 196, 251.

† *The New Astronomy*, p. 197.

* Carbon does not liquefy under ordinary conditions. In the production of his artificial diamonds, M. Moissan employed tremendous pressure and great heat; but the genuineness of his products has lately been denied.—Combes, *Moniteur Scientifique*, November, 1903.

† Sir R. Ball, "The Earth's Beginning," p. 243.

plane of the system, which would thus consist of a rotating nucleus encompassed by a wide zone of independently circulating meteorites. But this mode of development is not even approximately followed by comets. It would be possible only if they were isolated in space, and, in point of fact, their revolutions round the sun are of overwhelming importance to their destinies. The sun's repulsive energy causes them to waste and diffuse with expansion of splendid plumage. Under the sun's unequal attraction at close quarters they are subject to disruption, and the upshot of the tidal stresses acting upon them is the dispersal of their constituent particles along the wide ambit of their oval tracks.

We are, however, invited to look further afield. Cometary meteor-swarms may be only miniature specimens of the contents of space. Why should not remote sidereal regions be thronged with simular assemblages, colossal in their proportions, countless in number? And may they not supply the long-sought desideratum of a suitable "world-stuff" for the construction of suns and planets? From some such initial considerations as these, Sir Norman Lockyer developed, in 1887, an universal Meteoritic Hypothesis, designed on the widest possible lines, based on promising evidence, and professing to supply a key to the baffling enigma of cosmical growth and diversification. The meteoric affinities of comets formed its starting point; comets were assimilated to nebulæ; and from nebulæ were derived, by gradual processes of change, all the species of suns accessible to observation. The view was of far-reaching import and magnificent generality, but its value avowedly rested on a marshalled collection of facts of a special kind. In this it differed from the crowd of ambitious speculations regarding the origin of things by which it had been preceded. In this, it attained an immeasurable superiority over them, if only the testimony appealed to could be proved valid. Indeed, it is scarcely too much to say that, whether it were valid or not, the mere circumstance of having called the spectroscope as a witness in the high court of Cosmogony constituted an innovation both meritorious and significant.

The spectrum of the nebulæ was a standing puzzle. A theory which set out by making its meaning plain secured at once a privileged position. This was seemingly accomplished by Sir Norman Lockyer through the means of some simple laboratory experiments on the spectra of meteorites. Certain "low temperature" lines of magnetism given out by the vapours of stony aerolotic fragments were shown to fall suspiciously close to the chief nebular lines previously classed as "unknown." The coincidences, it is true, were determined with low dispersion, and were published for what they were worth; but they looked hopeful. Their substantiation, had it been possible, would have marked the beginning of a new stadium of progress. Nature, however, proved recalcitrant. The suggested agreements avowed themselves, on closer enquiry, as approximate only; magnesium-light makes no part of the nebular glow, and nebulium, its main source, evades terrestrial recognition. The light of cosmic clouds is, in fact, *sui generis*; it includes no metallic emissions; while the fundamental constituents of meteorites are metals variously assorted and combined.

The decipherment of the nebular hieroglyphics was the crucial test; its failure to meet it left the hypothesis seriously discredited; for coincidences between spectral rays common to nearly all the heavenly bodies naturally counted for nothing. Yet the investigation had its uses. The energy with which it was prosecuted, the ingenuity and resource with which it was directed, told for progress. There has been a clash of arms and a reorganisation of forces. Thought was stirred, observation and experiment received a strong stimulus, fresh affluents to the great stream of science began to be navigated. Efforts to prove what had been asserted were fruitful in some directions, and the work of refutation had inestimable value in defining what was admissible, and establishing unmistakable landmarks in astrophysics.

The discussion, however, threw very little light on the part played by meteorites in Cosmogony. Their world-building function remains largely speculative. Doubts of many kinds qualify its possibility, and lend it a fantastic air of unreality. But this may in part be due to a defect of imaginative power with which the universe is not concerned.

Waiving, then, preliminary objections, we find ourselves confronted with the essential question: Given a meteor-swarm of the requisite mass and dimensions, is there any chance of its condensing into a planetary system? Sir Norman Lockyer set aside this branch of his subject. His hypothesis was in fact "pre-nebular." He assumed that the small solid bodies with which it started would, in course of time, become completely volatilised by the heat of their mutual impacts, and that the resulting gaseous mass would thenceforward comport itself after the fashion prescribed by Laplace. Professor Darwin regarded the matter otherwise. It seemed to him possible to combine the postulates of the meteoric and nebular theories in a system planned on an original principle. For this purpose it was necessary to excogitate a means of rendering the kinetic theory of gases available for a meteor-swarm. "The very essence," he wrote,* "of the nebular hypothesis is the conception of fluid pressure, since without it the idea of a figure of equilibrium becomes inapplicable." M. Faye abandoned this idea; he built up his planets out of incoherent materials, thereby avoiding the incongruities, but forfeiting the logical precision, of Laplace's stricter procedure. Prof. Darwin consented to forfeit nothing; he stood forward as a syncretist, his object being to "point out that by a certain interpretation of the meteoric theory we may obtain a reconciliation of these two orders of ideas, and may hold that the origin of stellar and planetary systems is meteoric, whilst retaining the conception of fluid pressure." For the compassing of this end, he adopted a bold expedient. Fluid pressure in a gas is "the average result of the impacts of molecules." Fluid pressure in a meteor-swarm might, he conceived, be the net product of innumerable collisions between bodies to be regarded as molecules on an enormously magnified scale. The supposition is, indeed, as Kepler said of the distances of the fixed stars, "a big pill to swallow." From molecules to meteorites is a long leap in the dark. The machinery of gaseous impacts is obscure. It can be set in motion only by ascribing to the particles concerned properties of a most enigmatical character. These particles are, however, unthinkably minute; and in sub-sensible regions of research, the responsibilities of reason somehow become relaxed. We are far more critical as to the behaviour of gross, palpable matter, because experience can there be consulted, and is not unlikely to interpose its veto. Meteorites are doubtless totally dissimilar from molecules, however many million-fold enlarged; and they would infallibly be shattered by collisions which only serve to elicit from molecules their distinctive vibrations. Moreover, the advance of the shattering process would admittedly end the prevalence of fluid pressure. So that the desired condition, even if initially attained, would be transitory. There is, besides, a radical difference between a group of bodies in orbital circulation and a collection of particles moving at hap-hazard, unconstrained by any

* *Proceedings of the Royal Society*, Vol. XIV., p. 4.

predominant law of force. Professor Darwin's paper thus stands out as a monument of ingenious mathematical treatment applied to an ideal state of things.

An aggregation of revolving meteorites has no figure of equilibrium; and it is through the consequences necessarily resulting from this property that mathematicians are enabled to trace the progressive changes of a rotating fluid mass. In the absence of any such direct means of attack, their position regarding the problem presented by an assemblage of flying stones is not much better than that occupied by Kant, face to face with an evolving universe. It seems, however, clear that a meteor-swarm can condense only through the effects of collisions among its constituents. When the irregularities of movement upon which their occurrence depends are got rid of, the system must remain *in statu quo*. Order makes for permanence; a tumultuary condition is transient. The eventual state of the system can, however, be no more than partially foreseen. Bodies arrested in their flight should fall inward; hence a central mass would form and grow; but the production of planets would seem to be conditional upon the existence of primitive inequalities of density in the swarm. These might serve as nuclei of attraction for meteoric infalls, not yet completely exhausted, but plying with harmless fire one at least of the globes they helped to shape. There could, indeed, on this showing, have been no such harmonious succession of events as constituted the predominant charm of Laplace's scheme. The planets should be supposed to have issued pell-mell out of a chaos; or, rather, the chaos should have contained from the beginning the seeds of a predestined cosmos. Its evolution would have been like that of the oak from the acorn, an unfolding of what was already essentially there. And it may be that at this stage of penetration into the past, the unaided human intellect meets its *ne plus ultra*. There is a vital heart of things which we cannot hope to reach. Thought instinctively pauses before the vision of the symbolical brooding Dove.

To resume. Meteoric cosmogony deserves serious consideration. Materials for the purpose probably exist abundantly; and, in the solar system at least, they must have been formerly much more abundant than they now are. The earth has been raking up meteoric granules by hundreds of millions daily during untold ages, and her zone of space is still very far from being swept clean. The persistence of the supply, however, may be occasioned by the continual arrival of reinforcements from interstellar realms. Comets appertain to, and travel with the sun's cortège; and this is also inevitably true of comet-born meteors. But a multitude besides circulate independently of comets, and with much higher velocities. Their orbits are then hyperbolic; they belong to the category of "irrevocable travellers," and their capture provides us with genuine samples of sidereal matter. Universal space must contain them in vast numbers, yet there is nothing to prove their collection into swarms. The spectroscope supplies no assurance to that effect; it has given its verdict against the meteoric constitution of nebulæ and temporary stars. And if we admit, under the compulsion of mineralogical testimony, that the aerolites so strangely landed on terrestrial soil are really the *débris* of ruined worlds, we can see for them no chance of restoration. Solitary they are, even if they occasionally pursue one another along an identical track, and solitary they must remain. Bodies do not of themselves initiate mutual circulation. Planetary or stellar outcasts cannot become re-associated into a gravitational system. Of a cosmic swarm, as of a poet, it may be said, *Nascitur, non fit*; and their birth-secret is undivulged.

JUPITER AND HIS SURFACE CURRENTS.

By the Rev. T. E. R. PHILLIPS, M.A., F.R.A.S.

THE general aspect in the telescope of the planet Jupiter is well known. His markedly elliptical disc, which is distinctly brighter in the centre and gradually fades off towards the limb, is traversed by a series of dusky belts which vary from time to time both in width and position. These belts frequently show great irregularities at the edges, being broken up or indented by a number of light and dark spots, while dusky wisps are often to be seen projecting from them across the bright zones which separate them. The accompanying drawings will serve to illustrate the general arrangement of the surface features and also the great and rapid changes of aspect to which they are subject. Thus it will be seen from the illustrations that in the years 1896 and 1898 (Figs. 1 and 3)—as was also the case in 1901 and 1903—the belt lying North of the equator was quite narrow, but that at other times it was broad, and exhibited numerous condensations and white spots at its edges. It not infrequently happens that the general aspect of the planet undergoes a marked alteration even in the course of a single apparition. Thus Fig. 6 represents a view of Jupiter in June, 1902, but by the latter part of the autumn the appearance of the disc had materially changed. The equatorial regions were intensely white—a very striking contrast to the rich warm coppery tone which was so marked a feature of the planet a few years ago—and the whole of the disc North of the N. temperate belt was deeply shaded with a delicate bluish grey.

It is probable that some of the changes on Jupiter are of a cyclical or seasonal character. Mr. A. Stanley Williams in a valuable paper communicated to the Royal Astronomical Society in April, 1899, showed from a discussion of a large number of observations extending over many years that there is a remarkable variation in the colour of the two principal equatorial belts. Thus, when the S. equatorial belt is at a maximum of redness, the N. equatorial belt is at a minimum, or even bluish in tone, and *vice versâ*. The mean period of these variations is found to be about twelve years, and as this corresponds with the length of a sidereal revolution of Jupiter round the sun, it is probable that the change observed is of a seasonal character. The maximum redness occurs soon after the vernal equinox of the particular hemisphere in which the belt exhibiting it is situated. In accordance with the interesting conclusion at which Mr. Williams has arrived, the N. equatorial belt has lately been intensely red, and the S. equatorial belt almost colourless, except in the region immediately following the Red Spot bay.

But, perhaps, the most interesting and instructive feature hitherto observed in connection with Jupiter is the difference of speed with which his spots and other markings are drifting. So long ago as the latter part of the 17th century, Cassini found that the markings in the neighbourhood of the equator performed a rotation in nearly six minutes less time than was required by objects further north and south. Sir William Herschel, Schröter, and other observers confirmed this result, but as the outcome of the labours of more modern investigators, a considerable number of distinct currents are now known to control the movements of Jupiter's surface material. There can be no doubt that many recorded changes on Jupiter are in reality due to the great proper motions of the objects observed, which quickly cause them to become relatively displaced.

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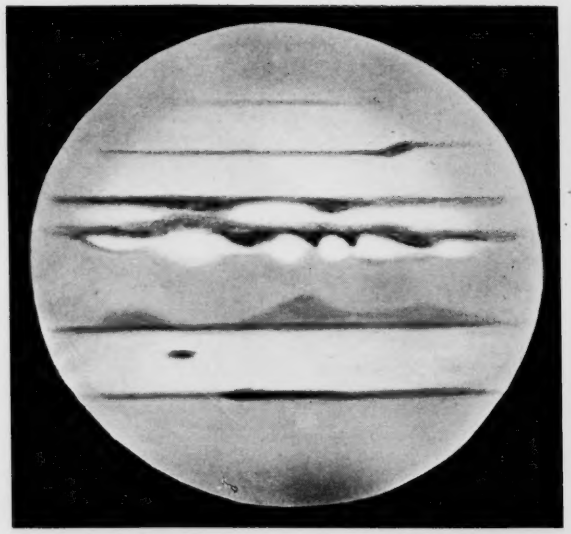

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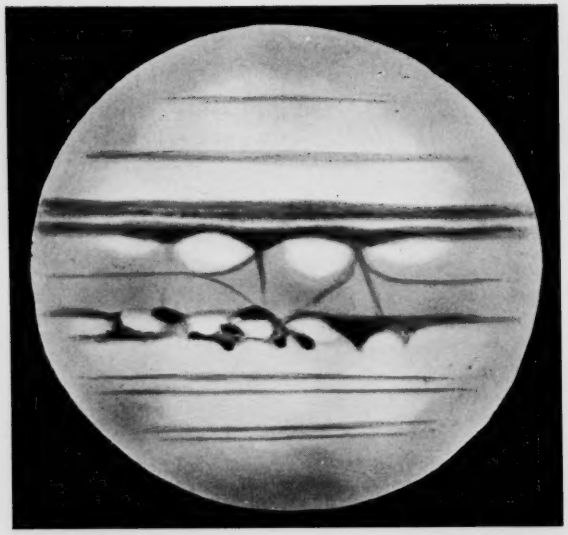

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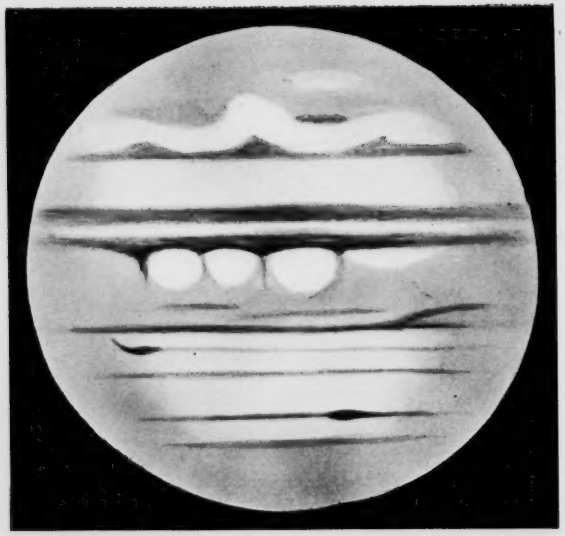

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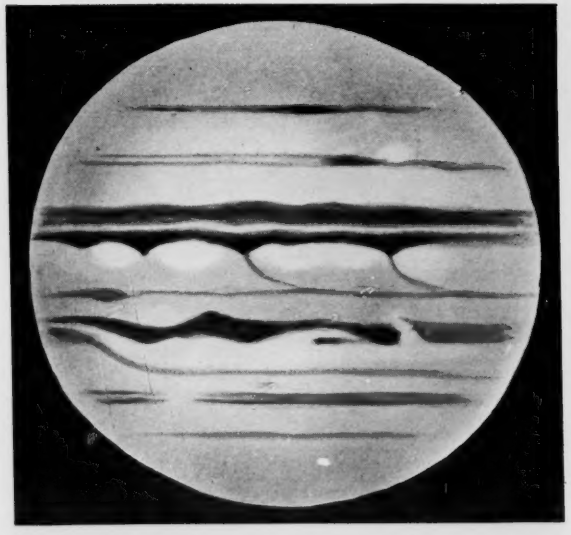

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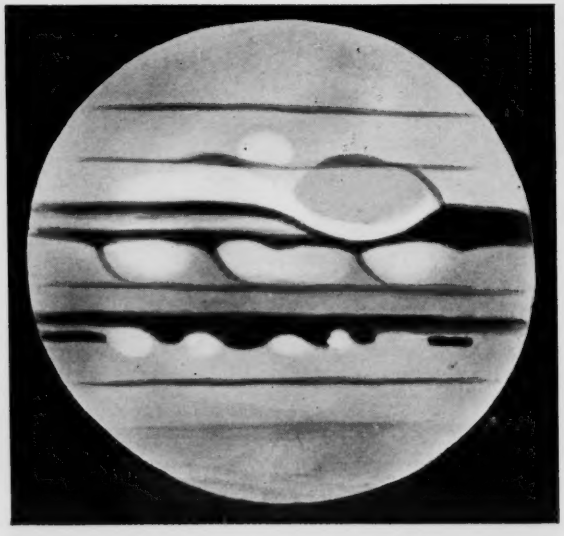
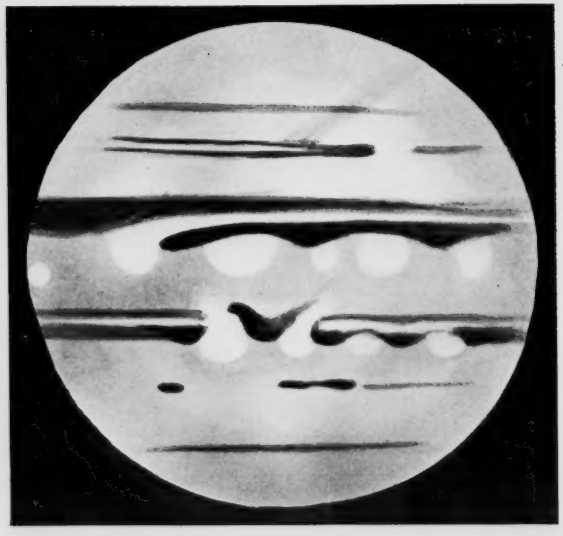


1900, April, 20d. 14h. 15m. G.M.T.



1902, June, 26d. 14h. 31m. G.M.T.

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With one or two exceptions these surface currents are pretty constant. Their velocity varies within certain limits, and the latitude of their boundaries is not always the same, but whenever definite spots or observable condensations appear their movements of rotation are nearly always found to conform more or less closely to the normal speed of that latitude. In an article in the February, 1903, number of *Popular Astronomy*, Prof. G. W. Hough questions the existence of several of these surface currents. Considering, however, the great mass of existing evidence, I venture to think that his conclusion is altogether unfounded, and that the reality of the currents is beyond dispute. In January, 1896, a valuable paper by Mr. A. S. Williams was published in the *Monthly Notices*, R. A. S., "On the Drift of the Surface Material of Jupiter in Different Latitudes." In that paper Mr. Williams brought together the results of numerous eminent observers in various years, and gave a clear account of nine separate and distinct currents. It is worthy of note that the arrangement of these currents, unlike those of the sun, is by no means symmetrical, neither is that of the two hemispheres the same. Moreover, the N. hemisphere contains in contiguity the swiftest and the slowest that have yet been observed.

The following table shows the general arrangement of these surface currents, but it must be understood that both the limiting latitudes and the rotation periods are subject to certain variations:—

No.	Latitude.	Rotation Period.	Remarks.
		h. m. s.	
1	+80° to +34°	9 55 37·5	From Polar Regions to N.N. Temp. belt.
2	+34° to +24°	9 54 30 / 9 56 30	From N.N. Temp. belt to N. component of N. Temp. belt.
3	+24° to +20°	9 48 0 / 9 49 30	S. component of N. Temp. belt.
4	+20° to +10°	9 55 32	N. Trop. zone and N. side of N. Equatorial belt.
5	+10° to −12°	9 50 20	Great Equatorial Current, comprising S. portion of N. Equatorial belt, Equatorial zone, and N. component of S. Equatorial belt.
6	−12° to −14°	9 51 30	Spots in bright rift dividing S. Equatorial belt.
7	−12° to −18°	9 55 40	S. component of S. Equatorial belt.
8	−14° to −28°	9 55 37	Great Red Spot.
9	−18° to −36°	9 55 18·5	From S. Trop. zone to S. Temp. zone.
10	−36° to −50°	9 55 6	S.S. Temp. belt, and bright zone S. of it.
11	−50° ±	9 55 23	Edge of S. Polar shading.

These currents must be discussed more in detail.

No. 1.—There appears to be some uncertainty as to how far north this current extends. In 1888 and again in 1892, Mr. Williams observed dark streaks which extended into very high N. latitudes and moved in accordance with the tabulated velocity. Since then Captain P. B. Molesworth, who has made quite a unique series of Jovian observations under very fine seeing conditions in Ceylon, has succeeded in detecting a number of light and dark spots and streaks in the Polar regions. Amongst these, he found in 1901 five dusky streaks in about latitude 50°, which gave a mean period of 9h. 56m. 3·7s. It is quite probable that the surface drift in these regions may be variable from year to year. More observations are much needed to settle the question of the minor, and at present doubtful, currents on the surface of Jupiter.

No. 2.—The drift in this region is not constant. At times when the N. hemisphere is in a state of disturbance spots are liable to appear which have a decidedly rapid rate of motion. As a general rule, however, it is found that markings in this neighbourhood exhibit the slowest movement of any on the disc.

No. 3.—This is unquestionably the most remarkable, as it is the swiftest, of all the Jovian currents. Our knowledge of it has been well summarized by Mr. W. F. Denning in a paper entitled "On a Probable Instance of Periodically Recurrent Disturbance on the Surface of Jupiter," published in *Monthly Notices*, R. A. S., December, 1898. It appears that at intervals of little more than ten years spots have frequently appeared on the S. side of the N. temperate belt which have exhibited a velocity which is extraordinary. As already pointed out, this swift current exists side by side with the slowest of the disc (No. 2), and taking their extreme values the difference of velocity amounts to about 365 miles per hour. It was thought that another outbreak of these rapidly-moving spots would occur at the end of 1900 or beginning of 1901. Unfortunately no such occurrence was observed, but it is quite possible that spots may have appeared and escaped detection, as in December, 1900, the planet was in conjunction with the sun.

No. 4.—This—commonly known as the N. Tropical Current—is another of the most important of the Jovian currents, and is generally in evidence. In some years when the N. equatorial belt is narrow, a number of dark spots are seen quite detached from this belt (*see* Figs. 1 and 3), and in 1898 and 1903 these were connected by a fine narrow line like beads strung on a thread. This narrow line is shown in Fig. 3 starting from one of these spots. On other occasions the N. equatorial belt extends so far north as to include this region, but it is found that the spots at its edge, which are often very numerous and definite, conform to the normal velocity of the N. Tropical Current, even though the S. edge of the belt be drifting at the same rate as the equatorial zone. I have given 9h. 55m. 32s. as the rotation period of this region, but it frequently happens that spots exhibit a period very considerably longer than this, and also very considerably shorter. A remarkable diversity of speed was apparent in this current in 1899. In that year I received a large number of transit observations of N. tropical spots from several observers, so that an ample amount of material was available for discussion. I had previously found from observations secured comparatively early in the apparition that a dark spot—shown in Fig. 4 lying in a distinct bay on the N. side of the N. equatorial belt—was moving at an altogether abnormal rate, but when the whole of the materials to hand were charted and examined, it was found that the spots between longitudes 140° and 260° had a mean rotation period of 18·5 seconds less than that of the remainder of the current. The exact values were 9h. 55m. 15·3s. and 9h. 55m. 33·9s. respectively. So far as I am aware so rapid a drift as that indicated by the former value has never been observed in this latitude before. Further, it was noticed that the limits of longitude which included this swift rotation were constant during the period covered by the observations. Spots starting from λ 260° quickly hurried forward, and rapidly-moving spots on arriving at λ 140° suddenly slowed down. A full account of this remarkable disturbance will be found in my paper on "The Extra-Equatorial Currents of Jupiter in 1899," published in *Monthly Notices*, R. A. S., January, 1900.

No. 5.—We now come to the Great Equatorial Current. The northern boundary of this current is variable. When narrow the whole of the N. equatorial belt appears to be included within its limits, but at other times only the southern component, or possibly the whole of the belt may lie without it. At any rate, spots near the N. limit of the zone frequently exhibit a period a few seconds longer than those at or near the N. edge of the S. equatorial belt. It is to these latter that most of the determinations of velocity in previous years refer. It is worth noticing

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that in 1879 the period was only about 9h. 50m., but, subsequently, increased steadily to 9h. 50m. 36s. in 1896. Since then the value has again declined, a sudden drop having been followed by somewhat irregular variations.

The following are the periods which I have found from a discussion of my own observations during the past few years :—

Year.	Number of Spots observed.	Rotation Period. h. m. s.
1898 ...	19 ...	9 50 24·2
1899 ...	34 ...	9 50 24·7
1900 ...	26 ...	9 50 23·7
1901 ...	24 ...	9 50 28·6
1902 ...	24 ...	9 50 27·8

A remarkable feature of the Great Equatorial Current is found in the peculiar wanderings or oscillations of the spots on each side of their mean or computed positions; and it frequently happens that a whole group of spots will share these vagaries of motion together. Despite these wanderings, however, there can be no doubt that many of the equatorial spots remain visible for long periods of time, but the fact that the planet is lost in the sun's rays, so far as satisfactory observations are concerned, for at least three months about the time of his conjunction—to say nothing of the difficulties caused by irregularities of motion and changes of form in the spots themselves—make their correct identification from year to year almost impossible.

No. 6.—A bright rift is usually seen to divide the S. equatorial belt into two separate components. During the last few years Captain Molesworth has followed a large number of bright spots in this rift, which appears to form a kind of transition stage between the two well-known periods of 9h. 50m. + and 9h. 55m. +. His rates for 1900 and 1901 are 9h. 51m. 37·3s. (from 17 spots) and 9h. 51m. 32·2s. (from 20 spots) respectively.

No. 7.—On the occasions when markings on the S. component of the S. equatorial belt have been observed and followed, it has been found that their period differs but little from the contemporary period of the Great Red Spot.

No. 8.—This can scarcely be called a current, as the surface material referred to under this heading is confined within the limits of the Great Red Spot. This remarkable object was detected in 1878 by M. O. Lohse, of Potsdam (who appears to have been the first to draw it), and by Professor Pritchett, of Missouri, and Mr. Dennett, of Southampton (whose observations seem to have been the earliest published), and quickly attracted general notice. Nearly every telescope was directed to its observation, and its behaviour carefully watched. It is elliptical in shape; its dimensions being about 27,000 miles in length, and nearly 9000 in breadth. What the nature of the spot may be it is impossible at present to say. Certainly it cannot be regarded as a solid feature of the planet's globe, since it is by no means stable in position; but, on the other hand, there can be no doubt that it is the product of forces which have considerable permanence, and, judging from the very definite and regular appearance of the well-known hollow or bay on the S. side of the S. equatorial belt in which the Red Spot lies (*see* Fig. 5), despite the present faintness of the spot itself, as yet show no signs of declining energy. A very interesting account of the early history of the Red Spot will be found in two valuable papers by Mr. Denning in the supplementary numbers of *Monthly Notices*, R. A. S., 1898 and 1899, and also in his article in this journal for August, 1902. In these papers Mr. Denning connects the present spot and hollow in which it lies with the ellipse seen by Mr. Gledhill in 1869, and with numerous similar objects which have appeared in the southern hemisphere at intervals since 1831. Indeed it is quite possible that the Red Spot of to-day may be identical with the remarkable object discovered by Dr. Hooke, so long ago as 1664. The determinations of the rotation period have been very numerous. Mr Denning, from a careful examination of existing material, and assuming his identifications to be correct, finds that in 1831 the period was 9h. 55m. 33·3s., that it increased to 9h. 55m. 38·3s. in 1859, again declined to 9h. 55m. 33·4s. in 1877, and once again increased to 9h. 55m. 41·9s. in 1899. In 1900 the rotational velocity exhibited a slight increase; in 1901 the spot remained almost stationary in longitude (as based on the period of 9h. 55m. 40·63s., adopted by Messrs. Marth and Crommelin as the value of their zero meridian of System II); and in 1902—from a discussion of about 100 transit observations of the spot and hollow secured by various observers—I find the period of the object to have been reduced to 9h. 55m. 39·3s. It should be added that the spot, in addition to its oscillations in longitude, like so many of the markings on the planet, has also a motion in latitude—the extreme drift being about 4000 miles. The deep red tone which distinguished the spot at the time of its appearance in 1878 soon proved evanescent, and the object is now but a ghost of its former self. In some years it has appeared merely as a faint elliptical ring; at others, the whole has just been visible as a feeble dusky stain on the bright zone in which it lies. Possibly it may be dimmed by the overlying vapours, but, as already stated, there is no reason to suppose that the forces which produce it are on the wane, and we may yet hope that at some future time it will reassume its former glory.

No. 9.—This is unquestionably the steadiest and most uniform of all the Jovian currents. It was detected by Schröter so long ago as 1787, since which time it has shown practically no variation. It extends over quite a broad zone, embracing the region between the S. edge of the S. equatorial belt, and the N. edge of the S.S. temperate belt. Observers of Jupiter will remember the remarkable S. tropical mass of dark material—extending eventually over about 90° of longitude—which swept round the S. side of the Red Spot during the summer of 1902.

No. 10.—This rapid current so far south is remarkable. It appears to be fairly constant and uniform, but has nothing in a similar latitude to correspond with it in the northern hemisphere.

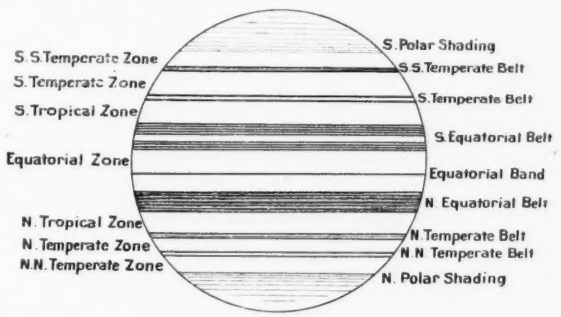
No. 11.—In 1901 Captain Molesworth detected a number of dark objects at the edge of the N. polar shading. These did not share in the rapid drift of the Great Southern Current (No. 10), but moved approximately at the tabulated rate. More observations are needed to establish the constancy of this current.

But interesting as is the investigation of these surface currents, the real nature of Jupiter's physical condition is the problem which students of the planet must endeavour to solve. It has generally been agreed that the belts and spots of Jupiter are of the nature of clouds and atmospheric vapours, that the true globe of the planet has never been seen; and that its real rotation period is consequently unknown. But whatever view may be adopted as to the vaporous character or otherwise of the visible features of the disc, it is probable that the internal body of the planet rotates in a period somewhat longer than any markings we can observe—possibly in a period just a minute or so less than 10 hours. As regards the relative altitudes of the various markings, there seems good reason to suppose that the more swiftly moving objects are situated at a greater height than those which move more slowly. Of course, it must be remembered that the planet may have no solid or definite surface divided off from the vapours which form its belts and spots. It is highly probable—bearing in

mind the very low density of Jupiter—that the whole globe is still in an intensely heated, semi-molten and viscous condition, and that what we see is but the outermost shell of visible material. Professor Hough, in his important and valuable paper already referred to, suggests that the visible boundary of Jupiter has a density of about one-half that of water, is of the nature of a liquid, and that in it are immersed the Red Spot and others whose motion in longitude and latitude are slow and gradual, and which are tolerably permanent or long enduring. He considers that the equatorial and other belts may be at the surface of this liquid or at a higher level than the Red Spot, and that the equatorial regions may be concealed by overlying vapours at a much greater altitude, in which openings and irregular condensations give rise to the appearance of white and dark spots.

No doubt there are many interesting questions in connection with Jupiter of which the solution must be left for future students; but this much, at any rate, we may suggest with some confidence:—We look at Mars and our own satellite, in them we see a forecast of physical conditions to which some day the earth must at least approximately attain. We look at Jupiter, and, in the constant agitation of his heated globe, we catch a glimpse, though on a giant scale, of our own world in the dim recesses of the past.

The accompanying diagram will enable the reader to



identify the various features referred to in the above article and depicted in the illustrations.

THE SHOWER OF LEONID METEORS IN 1903.

By W. F. DENNING, F.R.A.S.

TEMPEL'S comet (1866 I.) and the dense swarm of meteors in its contiguous region having passed through perihelion unobserved in 1899 the prospect of a fine shower of Leonids in 1903 appeared very doubtful. The meteors being, however, pretty thickly distributed along a considerable extent of the orbit, a fairly active recurrence of the shower was thought to be quite possible. Those observers who watched for its return on the morning of November 16 realised their best expectations. The Leonids were abundantly presented, offering the best meteoric spectacle observed in England since 1885, and forming the prototype, if far from being the parallel, of the grand exhibitions of 1799, 1833 and 1866.

The following are brief extracts from observations on the night following November 15, which have either been published or privately communicated to the writer:—

Backhouse, T. W., Sunderland.—Between 17h. 44m. and 18h. 5m., about 83 meteors per hour. A Leonid fireball seen at 15h. 49m. The Leonids were bright generally. Of 65 recorded, 1 being = Venus, 4 = Jupiter, 15 = Sirius, and 26 brighter than, or equal to, 1st magnitude stars.

Brook, C. L., Meltham, near Huddersfield.—Between 12h. and 15h. 30m., 52 Leonids were seen, after which clouds interfered. Very brilliant Leonid at 13h. 59½m., 2 × ♀, shot from 137½° + 8½° to 133° ± 0°. Radiant of shower, 150½° + 23°.

Corder, H., Bridgwater.—Between 17h. and 18h., about 200 meteors per hour. Estimated position of radiant, 149° + 22°.

Cruce, W. de, Exeter.—Between 16h. 25m. and 17h. 10m., 108 meteors observed.

Denning, W. F., Bristol.—The display watched between 12h. and 18h. 15m. Maximum, 17h. 30m. to 17h. 45m. 42 meteors. Radiant, 151° + 22°, about 6 degrees in diameter.

Ellison, Rev. W. F. A., Enniscorthy.—11h. 45m. to 12h. 45m., 5 Leonids; 12h. 45m. to 13h. 45m., 16 Leonids; 13h. 45m. to 14h 45m., 36 Leonids; 14h. 45m. to 15h., 11 Leonids; 15h. to 15h. 15m., 0 Leonids! Three fireballs seen, 13h. 40m., 153° + 43° to 185° + 28° (Taurid); 13h. 58m., 160° + 18° to 166° + 12° (Leonid); and 14h. 19m., 210° + 65° to 273° + 58° (Leonid).

Royal Observatory, Greenwich.—About 150 meteors seen, some as bright as Venus, the most prolific time being about 18h., when they appeared at the rate of 100 per hour.

Henry, J. R., Dublin.—15 Leonids seen in 15 minutes preceding 15h., and 20 in 15 minutes following that hour. Between 16h. and 17h. 30m. observer had the impression that meteors were appearing at the rate of from 200 to 300 per hour.

Herschel, Prof. A. S., Slough.—Not much short of 200–250 meteors per hour. Brilliant Venus-like meteors observed at 16h. 34m., 17h. 33m., and 17h. 41m.

Horner, Maures, Taplow.—During last hour of darkness counted 86 meteors, nearly all of which were Leonids.

Johnson, Rev. S. J., Bridport.—Several hundreds of meteors with the usual Leonid streaks and swift motions must have passed across the whole sky. 16h. 27½m., Leonid equal to Venus, 192° + 13° to 195° + 10°.

Knight, G. M., London.—November 14–17, 217 Leonids registered at Hampstead. Five fireballs seen with streaks, indicating radiant at 149½° + 23°. Maximum 17h. 30m., November 15.

King, A., Sheffield.—17h. 57m. to 18h. 3m., 18 Leonids. Hourly rate, about 200. Radiant, 148° + 22°.

Milligan, W. H., County Down.—Apparent maximum, 14h. to 16h., with horary rate of 80 to 100 for one observer. Radiant, 149° + 22°.

McHarg, John, Lisburn.—13h. 20m. to 14h. 20m., 20 Leonids, large proportion 1st magnitude; 13h. 45m., vivid green fireball from Taurus, 103° ± 0° to 112° − 6°.

Moffat, A. G., Swansea.—16h. 30m. to 18h., a brilliant display of large meteors; some green-coloured, the major portion, however, electric blue.

Service, R., Dumfries.—18h. 30m. to 19h., 42 Leonids observed.

Thompson, G. C., Cardiff.—Watching with a friend for several hours, only about 25 Leonids were seen; a number of other meteors radiated from Auriga.

Wright, F. H., Northampton.—15h. to 15h. 30m., 30 meteors; 15h. 30m. to 16h., 60 meteors; afterwards counted about 3 or 4 per minute. Maximum at about 17h. 15m., near which time 8 or 10 were several times counted in one minute, and 5 or 6 visible in the sky at the same instant.

The general results may be summarized as follows:—

Time of maximum, November 15, 17h. 40m.

Rate of apparition, 4 per minute for one observer.

Point of radiation, 150° + 22½°.

Character of meteors, bright generally, with streaks and swift motions.

Several Leonids and meteors belonging to contemporary minor showers were doubly observed, and their real paths have been computed. Among the latter there was a Taurid fireball, seen on November 15, about 13h. 42m., at Enniscorthy and Lisburn. It passed over the S.E part of Anglesea at heights from 72 to 32 miles, with a velocity of 23 miles per second. Radiant at 61° + 24°. A 2nd magnitude meteor appeared on November 15, 15h. 59m., directed from a radiant at 113° − 34°, and descending from 64 to 48 miles along an extended course of about 142 miles from over Sussex to Lincoln. Velocity about 19 miles per second, but the flight of the meteor seemed much retarded by atmospheric resistance, and at the end of its visible career, as observed at Bristol, it became almost stationary, its material and momentum being apparently quite exhausted.

Letters.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

LARGE *VERSUS* SMALL TELESCOPES IN PLANETARY WORK.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—In the course of his interesting article on Saturn in the current number of KNOWLEDGE, Mr. W. F. Denning has referred to the well-known fact of large telescopes sometimes failing to show faint planetary markings that were visible in those of much smaller aperture. The markings in question usually appear to be those having a considerable apparent area and a more or less diffuse and indefinite outline, and I do not remember to have ever seen any demonstration, either theoretical or practical, why markings of this nature should be any plainer or better seen as a whole in a large telescope than in a small one. As regards *minute* details there can, however, be no question as to the superiority of the large telescope.

But my present object in writing is to draw attention to the fact that the remarkable and instructive experiments on artificial markings, details of which have been recently published, seem to have an intimate bearing also on this question of the failure of large telescopes to show planetary markings visible in smaller ones. Particulars of one of these experiments having a special bearing on the subject, made by Mr. and Mrs. Maunder, have been recently published in the *Journal* of the British Astronomical Association, Vol. XIII., page 349. In this experiment two waved parallel lines when viewed at a distance of 130 feet, gave rise to the appearance of a faint, diffused band. On approaching nearer, the experimenters found, to their evident surprise, that this appearance after awhile began to get feeble, and finally *disappeared altogether* at a distance of about 100 feet. Nothing could then be seen at the place of the two waved lines until approach had been made to very nearly 60 feet, when the lines rapidly became distinct.

Now the employment of a larger aperture, and probably higher power, would no doubt be analogous in its effect to a diminution in the distance of the object, and hence, even assuming all other things to be equal, it does not seem difficult to conceive the existence of a particular kind of marking that would give rise to a distinct impression in a small telescope, although nothing whatever could be seen at the same place with a large one. For instance, a number of faint, irregular, narrow streaks crossing the bright equatorial zone of Saturn, perhaps analogous in their nature to the well-known equatorial "wisps" of Jupiter, and corresponding to the waved lines of the experiment, might give rise to an appearance of alternate faint and dark areas or spots in a small telescope, though a "giant" telescope might fail to show anything whatever of this appearance. Yet such apparent markings or spots, although not strictly objective, would clearly have an objective basis, and hence they would be suitable for determining the rotation period.

A. STANLEY WILLIAMS.

Hove, 1903, December 1.

THE ORCHID CEPHALANTHERA GRANDIFLORA.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—I have long had a thing to say about the fertilization of *Cephalanthera grandiflora*, and now that Mr. Praeger's interesting article on Orchids has appeared don't think I could fit it with a better time.

Figs. 1 and 2 represent respectively the front and side views of the column of this plant, and are drawn from life. What are the threads that cross and re-cross and attach themselves not only to the stigma but to the front of the column and sides of basal portion of labellum, like the supporting strands of a spider's web? If they are pollen

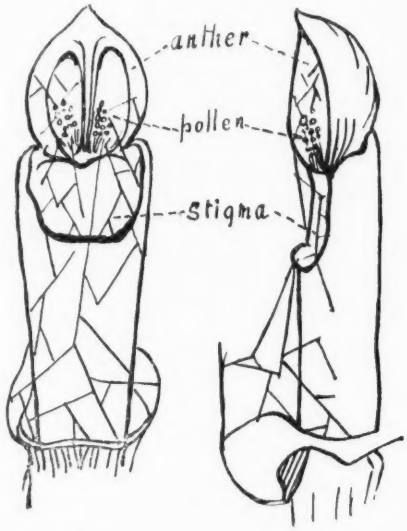


FIG. 1. FIG. 2.

tubes, why the curious reticulation? At first I thought the meshes were caused by pollen grains falling upon different parts of the column, whence they might germinate in any direction, but, in spite of Darwin, who says the grains "readily adhere to any object," I have tried to remove them at all stages of development and not one grain could I get away, not even with the hairy edge of a piece of blotting paper; now I am thinking that the earliest tubes as they elongate may drag out and carry down from the pollinia grains that may be later in germinating, and would thus add meshes to the net. How does my supposition stand? I should add that pollen masses almost entirely disappear when the threads are most numerous.

C. E. CLARK.

24, Iffley Road,
Hammersmith, W.,
November 16th, 1903.

A FOG BOW.

TO THE EDITORS OF KNOWLEDGE.

SIRS,—I should like to know if any of your readers can explain a strange phenomenon which I saw whilst travelling to Brighton from Hastings by train, about 7 o'clock on the evening of the 30th of September last. The night was hazy, and looking through the open window I distinctly saw outlined against the sky a circle, or rather an oval-shaped bow enclosing a long cross; the lower part of the vision being veiled in mist, the tones were neutral and soft, though clearly defined. It disappeared from view suddenly, and though I watched for quite half-an-hour, it did not appear again. The train at this time was running through the flat marshy country, known, I believe, as Pevensey Level, therefore skirting the sea-shore. A picture of a similar appearance in Whymper's "Scrambles amongst the Alps," recalled the circumstance to me.

Beckley. MARY FRASER.

Obituary.

HERBERT SPENCER.

It is with deep regret that we record the death of Mr. Herbert Spencer, which occurred in the early morning of the 8th of December, at his house in Brighton.

The last survivor of the many eminent men of his time, Spencer enjoyed the unique distinction of completing the stupendous task he had set himself as the purpose of his life, a task which occupied him for the long period of thirty-six years (1860-1896). It is doubtful whether the history of letters contains a more remarkable instance of the amazing results of courage and tenacity than is found in the production of Spencer's Synthetic Philosophy. "How insane my project must have looked to onlookers," he says, when with his small resources frittered away, and his health permanently impaired by overtax of brain, he was obliged to desist by reason of nervous breakdown actually before the first chapter of the first volume was finished. But the philosopher afterwards pursued his course undeterred, and he completed it with the expression of the modest satisfaction that losses, discouragements, and shattered health had not prevented the fulfilment of his long task.

Born in Derby on the 27th April, 1820, the son of a teacher of mathematics, he shared with John Mill the distinction of having his education directed entirely at home, although in Spencer's case an uncle assisted the father. But he never had any experience of school or college, and he early abandoned his profession in order to devote himself entirely to speculative thought. Spencer's long career is singularly uneventful in personal history, and it is certainly by no desire of his that the world knew anything about him. But as a frequent contributor to the *Westminster Review*, in his earlier days, Spencer was brought into contact with many of its then brilliant writers, and his striking originality was displayed in association with Hamilton and the two Mills. From the year 1860, when the philosopher first resolved to concentrate himself upon his great project, Spencer's own life is little more than the story of the publication of the successive parts of his system of Philosophy, until that happy day in 1896, when he reached the close of his long labour, and found pleasure in his emancipation. He had the felicity to receive a congratulatory address from his contemporaries eminent in science, literature, and philosophy, and arising out of that address, Mr. Hubert Herkomer painted the well-known portrait which is exhibited in the Tate Gallery. In joining the signatories to this address, Mr. Gladstone most aptly expressed the general feeling as to Spencer's unselfish labours . . . "I beg that you will, if you think proper, set me down as an approver of the request to Mr. Spencer, whose signal abilities and, rarer still, whose manful and self-denying character are so justly objects of admiration."

British Ornithological Notes.

Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

Bird Migration in Solway, by Robert Service, M.B.O.U. (Annals of Scott. Nat. Hist., 1903, pp. 193-204).—This is an interesting and distinctly valuable article of actual observation of bird migration. Of the arrival of birds, such as Finches and Warblers, Mr. Service writes:—" . . . it requires the minutest attention to see the individual birds arrive one by one. They seem to drop literally from the clouds Let one's attention be diverted for a moment, next time you look at a particular place there are one, or two, or three birds that were not on the spot last time you glanced at it." Of the call notes heard during the progress of a great migratory movement at night, he writes:—"There is not one of us but will be confounded and humiliated to find that a very large proportion of the sounds cannot be assigned to any known species with certainty. Of course, the explanation lies in the fact that birds when on migration use notes that are not required at other periods of their lives." Of the altitude at which birds migrate the writer states:—"Skylarks and Swallows are about the only birds I am acquainted with that migrate at a comparatively low level. Quite invariably other birds that I have seen actually starting on their long journey mount very quickly upwards in a slanting direction, till they reach a height at which they can only be recognized by some peculiarity of flight." There are many interesting observations in this paper. Mr. Service has not read, apparently, Mr. Eagle Clarke's valuable papers on the subject, and the records of his own actual observations have been uninfluenced, seemingly, by those of others.

Barred Warbler in Lincolnshire (*Zoologist*, 1903, p. 363).—In an account of the migration of birds in North-east Lincolnshire during the autumn of 1902, Mr. G. H. Caton Haigh records that he shot a young female of this Warbler at North Cotes on September 20th. This is, I believe, the third specimen of the Barred Warbler which Mr. Haigh has recorded, and the eighteenth or so which has occurred in the British Islands.

Sabine's Gull in Yorkshire (*Zoologist*, 1903, pp. 353, 394, 436).—The Rev. Julian G. Tuck has now recorded the occurrence of five (four adults) Sabine's Gulls in September and October last on the Yorkshire coast. This arctic species not infrequently visits our shores in autumn, but most of the previous records have referred to immature birds.

Rare Birds in Kent and Sussex (*Zoologist*, 1903, pp. 418-425).—Mr. N. F. Ticehurst here tabulates the remarkable number of rare birds which it has fallen to the lot of ornithologists in Sussex and Kent to record during the last twelve months. The most noteworthy of these have already been reported in these columns.

All contributions to the column, either in the way of notes or photographs, should be forwarded to HARRY F. WITHERBY, *at the Office of* KNOWLEDGE, 326, *High Holborn, London.*

Notes.

ZOOLOGICAL.—According to recent information, the white rhinoceros (*Rhinoceros simus*), at one time believed to be all but extinct, appears to be comparatively common on the northern frontier of the Congo Free State and the adjacent districts of the Sudan.

The important anthropological and zoological collections brought home by Messrs. Robinson and Annandale from the Malay Peninsula are to be described in a new publication, entitled *Fasciculi Malayenses*. The first part, containing an account of Mammals, by Mr. J. L. Bonhote, has already been issued. Sixty-four is the approximate number of mammalian species included in the collection, of which eight are described as new.

Great interest attaches to the description by Dr. Max Schlosser, of Berlin, in the *Abhandlungen*, of the Royal Bavarian Academy, of a large collection of fossil teeth of mammals obtained from the druggists' stores of various parts of China, where they are sold as medicine. Many of these teeth—locally known as dragons' teeth—appear to be obtained from caverns, but others probably come from the loess, or alluvium, while yet others are derived from older formations. Judging from the quantities in which they are sold in the bazaars, these teeth must exist in enormous numbers in some parts of the Chinese Empire. The remains include those of deer, antelopes, three-toed horses (*Hipparion*), rhinoceroses *Chalicotherium*, ancestral forms of camel (*Paracamelus*), giraffes, okapi-like ruminants, pigs, hyænas, and sabre-toothed tigers. One of the hyænas (*Hyæna gigantea*) is by far the largest of its tribe, the upper carnassial tooth measuring two inches in length against one-and-a-half inches in the existing spotted species of Africa. Especial interest attaches to the ancestral camel, since North America is supposed to have been the original home of the *Camelidæ*, and that continent was in close connection with north-eastern Asia in Tertiary times. Not less noteworthy is the occurrence of remains of antelopes of an African type, as well as of others allied to the Indian nilgai. This seems to refute the theory that the antelopes of Africa originated in that continent (where the nilgai, which is a near relative of the kudu and bushbucks, is unknown), and to confirm Prof. Huxley's hypothesis that they are really immigrants from Asia.

At the first meeting of the Zoological Society for the present session, Mr. O. Thomas described a gigantic rat from New Guinea, which he regarded as representing a new genus, and named *Hyomys meeki*.

A fortnight later, at the second meeting of the same body, Mr. R. I. Pocock called attention to a remarkable habit of the Australian spiders of the genus *Desis*. These spiders live in the crevices of rocks between tide-marks on the shore, and by spinning a closely-woven sheet of silk over the entrance, imprison a mass of air in which they are able to live during flood-tide.

Two interesting additions have been recently made to the British vertebrate fauna. Till 1899, when it was detected on the coast of Brittany, the giant goby (*Gobius capito*) was believed to be a purely Mediterranean fish. During the past summer, Mr. F. Pickard-Cambridge, by carefully searching the rock-pools, has discovered this fish on the Cornish coast. One of his specimens is figured in *The Field*.

The second addition is an entirely new species of bank-vole (*Evotomys skomerensis*), from Skomer Island, off the Pembrokeshire coast. According to its describer, Captain Barrett-Hamilton, this species differs from the common bank-vole (*E. glareolus*) not only in colour and size (being much larger), but also in the structure of the skull; it belongs, in fact, to a distinct group of the genus. The description of this new species appears in the *Proceedings* of the Royal Irish Academy.

The Americans are contemplating a great undertaking; nothing less than a complete biological survey of the Eastern Holarctic (or Palæarctic) region, that is to say, of the greater part of the extra-tropical area of the northern hemisphere. The proposed survey is to be undertaken on the lines of the one which is being brought to a conclusion in the United States, and it is calculated that it will take ten years to accomplish. The funds are to be supplied by the Carnegie Institute. Such a survey, it is urged, would alone enable us to understand the true relationship of the fauna of Northern Asia and Europe to that of North America, and would likewise help to explain the origin of both faunas. According to American ideas, the vast amount of material contained in the museums of Europe is of little or no use for such a purpose; and it is in contemplation to collect the whole vertebrate fauna of this vast area section by section. If the project be carried through, we may expect to be inundated with descriptions of so-called new species, comparable to the seventy which have just been named from the islands of Malaysia, by Mr. G. S. Miller, in a paper published in the "Miscellaneous Collections" of the Smithsonian Institution.

Dr. W. G. Ridewood recently exhibited to the Linnean Society the frontal bones of a horse showing a pair of rudimentary horns, very similar in position to those of some of the ruminants. In the opinion of the exhibitor, this feature can hardly be regarded as an instance of reversion, since none of the extinct ancestors of the horse, of which (as indicated in an article in our present issue) the series is remarkably complete, show any traces of similar appendages. It is unfortunately not known whether the bony cores were covered in life with horn. This interesting specimen has been presented by Mr. A. Broad, of Shepherd's Bush, to the British (Natural History) Museum, where it is now exhibited.

Notices of Books.

"BRITISH MAMMALS: AN ATTEMPT TO DESCRIBE AND ILLUSTRATE THE MAMMALIAN FAUNA OF THE BRITISH ISLANDS FROM THE COMMENCEMENT OF THE PLEISTOCENE PERIOD DOWN TO THE PRESENT DAY." By Sir Harry Johnston. (Hutchinson.) Illustrated. Price 12s. 6d.—The author of this handsome addition to the "Woburn Library" is apparently convinced that it is illogical to separate the animals of to-day from those of yesterday, and he accordingly includes in his account of the mammals of the British Islands not only those now to be met with there in a wild state, but likewise those that have been exterminated within the historic period, together with those extinct forerunners of the latest geological epoch. Whether this method is any more logical than the one which excludes extinct types may well be a matter of opinion, for if the animals of yesterday come within the scope of the work, there is no reason why those of the day before should be left out in the cold. Accepting, however, both his extension and his limitation of the subject, we think that Sir Harry Johnston has succeeded in producing a very readable and attractive book, and one which may, in its general scope and style, well form a model which more scientific zoologists would do well to copy. An absence of details is noticeable, and the relations of the few surviving British mammals to their relatives in other lands and to their extinct predecessors are sketched in a manner which cannot fail to interest. Indeed, the work is much more than is indicated by its title, since it treats largely of mammals in general.

While commending the general style of the work, we must at the same time warn our readers that it must by no means be accepted as an exhaustive account of British mammals, or one that is free from errors. For instance, while in the case of one species of the mouse tribe the local sub-species are given, in some of the others they are omitted. This, of course, is inexcusable. It would have been perfectly legitimate to ignore sub-species *in toto*, but to notice them in one case and omit them in others, can only be taken to mean either that the author is inexcusably careless, or that he knows his subject imperfectly. We might also refer to certain inconsistencies in regard to nomenclature, did space permit. To justify the assertion that the book is by no means free from serious errors, we may cite the statement on p. 269 to the effect that ancestral rhinoceroses had four toes on each foot, and also the one on p. 370 that

Macaque monkeys are the only representatives of their kind which in Asia inhabit districts with a climate as cold as that of England. The author's theories, too, must be accepted with reserve—notably the suggestion (p. 366) that American monkeys originated in Africa, seeing that not a vestige of the remains of one of these creatures has hitherto been discovered in that continent.

A striking feature of the volume is formed by the coloured plates (reproduced from the author's own sketches), which differ markedly in style from the illustrations commonly seen in zoological works. As to the merits of these sketches, we must, however, leave our artist friends to decide.

"THE MOON: CONSIDERED AS A PLANET, A WORLD, AND A SATELLITE." By James Nasmyth, C.E., and James Carpenter, F.R.A.S. (Murray.)—The moon is a dead and unchanging world. As it was when Galileo looked upon it through the first telescope, so it was when Nasmyth and Carpenter brought out the third edition of the "Moon" in 1875, and so it is to-day, when the publishers have issued a verbatim reprint of the same book. Perhaps it is because of its unchangeableness that so little progress in our knowledge of the moon seems to have been attained in the last quarter of a century or more, for the joint authors raise the same problems, and give the same doubtful answers to the same questions that we do to-day. The book is in fact up-to-date for all intents and purposes. In illustration alone do we seem to have made a notable selinographical advance. When Nasmyth and Carpenter wrote, photography was a very unskilful assistant to the study of the moon, and their lunar drawings were (as they still are to-day) incomparably the finest representations made by hand of the moon's surface. The re-publication of the book in a more convenient size, and at the greatly reduced price of 5s., will meet with wide acceptance. The paper and print are both pleasing. We notice one misprint on p. 79, where $\frac{1}{1000}$ is written for $\frac{1}{1000}$.

"MINUTE MARVELS OF NATURE." By John J. Ward. (London: Isbister & Co.)—The aim of the author of this book is to exhibit in a popular manner some of the striking and interesting subjects which are revealed by the microscope, and to describe them in such a way as will attract the unscientific reader. To this end the book is freely and admirably illustrated by 184 reproductions, principally photo-micrographs, and they cover a very large range of subjects. Bearing in mind the purpose of the book, the critical judgment is largely suspended. Errors there are, but not such as substantially weaken its object. A microscopist is apt to become a little impatient when he sees a group of specimens which includes Anchors and plates from the skin of the Synapta included in the title of "Diatoms." Several other little blemishes occur, and the description of the manner of the use of the pulvilli of the fly's foot—for so long a subject of controversy—might with advantage be revised. Still the book, placed in the hands of one who is unacquainted with microscopical subjects, is likely to create interest and lead to a desire for further information and investigation; if it succeed in this, its purpose will be achieved.

"BUDDIST INDIA." By Prof. T. W. Rhys Davids. Pp. xv. + 332. (Fisher Unwin.) Illustrated. 5s.—The rise of Buddism in India has provided Prof. Rhys Davids with a theme for a scholarly work. If India were subject to a nation like Germany, exploration of the rich field of historical research, of which this book gives us an inspiring sketch, would be made a subject of national concern; but here it is not considered necessary to make inquiries into the ethnology or archæology of the races which constitute our Empire, and it is left to scholars like Prof. Davids to rescue such knowledge from oblivion. It is usual to adopt the Brahmin idea of ancient India, with its doubtful theories of castes and history, but inscriptions and other records have provided material for the construction of a connected account of India without accepting the Brahmin point of view as the final one, and equally true five centuries before Christ and five centuries after. Prof. Davids describes from the available evidence the kings, clans and nations, social and economic conditions in India in the sixth and seventh centuries B.C. The Buddist influence was most early felt in the north of India, and the picture of village life at that time shows that the "mass of the people, the villagers, occupied a social grade quite different from, and far above, our village folk." The claim of the priests to social superiority was not recognized and the caste system as it is now understood was unknown. There were different families or clans, but the caste system, in the exact use of the term, did not come into existence until long afterward. As to literature, the oldest reference to writing is in a tract dating approximately to 450 B.C. The priests appear to have been indifferent and even opposed to the use of writing. "All the present available evidence," remarks Prof. Davids, "tends to show that the Indian alphabet is not Aryan at all; that it was introduced into India by Dravidian merchants; and that it was not, in spite of their invaluable services in other respects to Indian literature, to the priests, whose self-interests were opposed to such discoveries, but to traders, and to less prejudiced literary circles, that India owes the invention of those improvements in the mechanical aids to writing that enabled the long previously existent knowledge of letters to be applied at last to the production and preservation of books." Limitations of space prevent us from mentioning more of the interesting points with which this volume is filled. Buddism slowly but continually lost its place as a national faith and now there is scarcely a Buddist left in the land where Buddism arose. Changes in the faith itself, changes in the intellectual standard of the people, and the influence of foreign tribes which invaded India from the north-west, are suggested as causes for the decline and fall of Buddism in India. Prof. David's story of the rise of the faith, and the conditions of the people who professed it in India, is a contribution worthy of his great learning, and of great interest to every student of history.

"OBSERVATIONS OF A NATURALIST IN THE PACIFIC BETWEEN 1896 AND 1899." By H. B. Guppy, M.B., F.R.S.E. Volume I. "Vanua Levu, Fiji." Pp. xx., 392. (Macmillan.) 15s.—This book is the work of one who does not shrink from detail; and it has more in common with the elaborate memoir of a State survey than with the ordinary record of a traveller. In a country where the annual rainfall varies from 100 to 250 inches, where the interior tends to become wilder and less populous, and where dense forest prevents the mapping of geological boundaries, Mr. Guppy has made elaborate notes of every rock-exposure that he could visit. He includes the fine volcanic necks that rise sheer above the agglomerate layers and the marine sediments of the plateaux; and he shows how the general volcanic action took place in Cainozoic times beneath the sea. Inclining, evidently, to a theory of upheaval, rather than to the difficult hypothesis of a recession of the level of the sea, he yet does not absolutely commit himself on this important subject. His unwillingness to generalise makes the book rather serious for the reader. The types of lava met with are classified with what seems an excess of detail, seeing that nothing new is revealed concerning their behaviour or occurrence as rock-masses. The felspar crystals are carefully measured under the microscope, and the presence or absence of fluidal structure in the ground-mass is noted in each case. In dealing with the felspars which are commonly called "laths" by workers with the microscope, Mr. Guppy prefers the fourteenth century term "lathes." His phrase "lamellar extinction," moreover, does not strike us as a very happy one. Still less do we like the "formulæ" devised for the comparison of one rock with another. This is all very well for the note-book of one who is correlating a large series, but such a system seems hardly necessary in the published work This cumulative evidence as to the interstratification of marine sediments and volcanic *débris* throughout Vanua Levu is of wide interest and importance; the minimum emergence (p. 315) that has made the present island is valued at 2500 feet. The history is one of a struggle between the forces of elevation and the constant planing action of the sea. A rise of another 600 feet would connect Vanua Levu with its sister island, Viti Levu, on the south-west. The plateau that forms a floor for the later accumulations is regarded as due to spreading lava-flows (p. 373). Similar plateaux, completed in Oligocene times, and now buried in marine sediments, would doubtless be revealed by local elevation in the region between Ireland and the Faröe Isles. The whole book is admirably produced, but we cannot help thinking that it would have gained by considerable excisions, and by the substitution of a classified list of the localities from which specimens had been collected, in place of the detailed descriptions of so many individual instances.

XUM

"AMONG THE NIGHT PEOPLE." By Clara D. Pierson. Pp. xii. + 221. (John Murray.) 5s.—It may be doubted whether any useful scientific purpose is served by regarding the lower animals as reasoning creatures possessed of sentiments like those of human beings and a vocabulary superior to that of many people. In the dainty book before us not only do raccoons, rats, foxes, weasels and other "varmin" carry on animated conversations, but also mosquitoes, caterpillars, fireflies and moths. Children have no difficulty in imagining a doll or rocking horse to be endowed with life, so that the stories in this book will appeal to them vividly. Regarded as food for imagination, comparable with fairy tales and classical legends, the stories are very good and will please many young people. As for natural history, well, there is a vein of it among the whimsicalities described and the fine feelings pourtrayed, but the pity of it is that children will be unable to discriminate between what is real and what imaginary.

"MATHEMATICAL CRYSTALLOGRAPHY AND THE THEORY OF GROUPS OF MOVEMENTS." By Harold Hilton, M.A. Pp. xii. + 262. (Clarendon Press.) 14s. net.—Earnest students of crystallography will be grateful to Mr. Hilton for his treatment of a branch of the subject usually neglected in English text-books. The geometrical theory of crystal structure is a fascinating field of study which the mathematician and the crystallographer can explore to the mutual advantage of both. From considerations of symmetry and finite groups it is shown that there are only thirty-two groups of movements consistent with the law of rational indices, and therefore applicable to crystallography. The argument thus develops the thirty-two crystal classes given in text-books on the subject. Three chapters are devoted to the description of the more important properties observed in crystals, and with chapters, among others, on the points already mentioned, form the first part of the book. The second part is devoted to theories suggested to account for these properties, the methods and notation used by Schönflies in his "Krystallsysteme und Krystallstructur" being closely followed. The work of other investigators of the geometrical theory of crystal structure, which may now be regarded as fairly complete, is included, so that the volume is of importance both for reference and as a supplement to modern text-books.

BOOKS RECEIVED

Direction of Hair in Animals and Men. By Walter Kidd, M.D., F.Z.S. (A. & C. Black.) Illustrated. 5s. net.

The Cosmos and the Creeds. By Capt. W. Usborne Moore. (Watts.) 4s. net.

The Signs of Life. By Augustus D. Waller, M.D., F.R.S. (Murray.) Illustrated. 7s. 6d. net.

Essays and Addresses, 1900—1903. By the Rt. Hon. Lord Avebury, P.C. (Macmillan.) 7s. 6d. net.

Eton Nature Study and Observational Lessons. By Matthew Davenport Hill, M.A., F.Z.S., and Wilfred Mark Webb, F.L.S. (Duckworth & Co.) Illustrated. 3s. 6d. net.

School Geometry. Part V. By H. S. Hall, M.A., and F. H. Stevens, M.A. (Macmillan.) 1s. 6d.

Infection and Immunity. By Geo. M. Sternberg, M.D., LL.D. (Murray.) 6s. net.

St Anselm. Proslogium; Monologium; An Appendix in behalf of the Fool by Gaunilon; and Cur Deus Homo. Translated by Sidney Norton Deane, B.A. (Kegan Paul.) 5s. cloth.

Evolution and Adaptation. By Thomas Hunt Morgan, PH.D. (Macmillan.) 12s. 6d. net.

New Theory of Organic Evolution. By James W. Barclay. (Blackwood.) 3s. 6d. net.

Some Indian Friends and Aquaintances. By Lt.-Col. D. D. Cunningham, C.I.E., F.R.S. (Murray.) 12s. net.

The Canon of Reason and Virtue. Translated by Dr. Paul Carus. (Kegan Paul.) 1s. 6d.

Guide to the Civil Service. By John Gibson, M.A. (Hodder & Stoughton.) 3s. 6d.

Education: Intellectual, Moral, and Physical. By Herbert Spencer. (Rationalist Press Association.) 6d.

Journalism as a Profession. By Arthur Lawrence. (Hodder & Stoughton.) 3s. 6d.

Publications of the Lick Observatory. Vol. VI. 1903. Meridian Circle Observations.

Annual Report of the Smithsonian Institution, 1902.

On the Absorption and Emission of Air and its Ingredients for Light of Wave-Lengths. By Victor Schumann. (Smithsonian Institution.)

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Who's Who Year Book, 1904. 1s. net.

Whitaker's Almanack, 1904. 2s. 6d net.

Whitaker's Peerage, 1904. 3s. 6d. net.

Annual Report of the Smithsonian Institution, 1901 (U.S. National Museum.)

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Bulletin du Jardin Botanique de L'État à Bruxelles. September, 1903.

Agriculture, Live Stock, and Dairying in Argentina. By Robert Wallace. (Edinburgh: Oliver & Boyd.) 9d.

Williams and Norgate's International Book Circular 137. 6d.

The Burlington Magazine. December. 2s. 6d. net.

Ross Limited Abridge Catalogue, 1903.

Newton & Co. Supplementary List of Lantern Slides, 1903–4.

THE ANCESTRY OF THE HORSE.

By R. LYDEKKER.

IF an expert mechanical engineer, totally unacquainted with zoology and comparative anatomy, were shown for the first time the skeleton of a tapir, and told that it belonged to an animal adapted to life in swamps, and were then asked if he could suggest improvements in the structure of the bony framework in order that the animal might be suited for a life on the open plains, and possess a high turn of speed, there would be little doubt as to the nature of his answer. After examining the short limbs, with two parallel bones in the second segment, and their three or four toes each, he would at once say that it is essential to lengthen all the bones of these portions of the skeleton, and to reduce the width of the foot either by diminishing the size of all the toes except the large middle one (which would have to be proportionately increased), or by doing away with them altogether. He might further suggest that it would be important to lengthen the bones of the lower segments of the limbs (except, of course, the three terminal ones) to a much greater extent than the upper one. And if he were specially inventive he might also point out that a much greater stride and far more mechanical power would be gained, if the animal could be made to stand only on the extreme tips of its toes, so that the whole of the hinder portion of the foot would be raised above the ground. Further, he might also advise that it would confer strength and solidarity on the limbs if the two bones in the second segment of each were welded together, so as to form but one.

If, moreover, he were told that the tapir is probably a short-lived animal, which feeds on soft marsh vegetation, and that it was essential to obtain an animal whose span of life should be from fifteen to twenty years, and whose food should consist of dry grasses and grain, he would naturally look at the molar teeth of the tapir. These he would find to have low crowns surmounted merely by a few simple ridges; and if the skeleton belonged to an old individual, he would not be long in discovering that some or all of them were worn nearly or quite down to the roots. Obviously his answer would be that the crowns of the teeth must be very considerably lengthened; and, moreover, so constructed as to be more capable of resisting wear, and better adapted for grinding hard substances than are those of the tapir.

After this inspection of the skeleton of the tapir, we

must imagine our engineer to be introduced to that of the horse. "Here we have," he would say, "the very ideal animal you want, and I can suggest absolutely no mechanical improvement in its framework, save that I fail to realise the use of the two small splints of bone attached to the sides of the upper part of the cannon-bone in each limb."

Here, indeed, we have in a nutshell the essential difference between the horse (and its near relatives the zebras and asses) and its early ancestors, which, although of

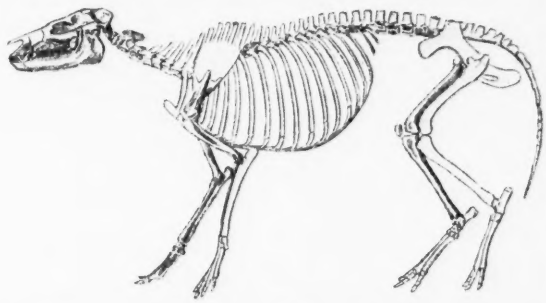


FIG. 1.—Skeleton of *Hyracotherium*, of the Lower Eocene Period in North America and Europe. (After Cope.)

smaller size, were generalized creatures not far removed in their organization from the tapir. In the ancestral type there is abundant room for modification and specialization, whereas in the other the possibilities of improvement and advance appear to have been exhausted, and the animal is (with the aforesaid exception) practically perfect for its own special mode of life, and is the supreme development of which its line is capable. The mode in which this perfection has been attained during the slow course of evolution, it is my purpose, so far as space permits, to demonstrate in the present article.

The earliest mammal to which we can at present definitely affiliate the horse and its relatives is one from the lowest part of the lowest, or Eocene, division of the Tertiary period known as *Phenacodus*. This was a short-legged creature not larger than a fox, with a relatively small head, long tail, and five toes to each foot. On these five-toed feet the creature probably walked much in the same way as the modern tapir, that is to say that although the wrist and ankle joints were raised well above the ground, all the three bones of each toe were applied to the same, and the sole was provided with cushion-like pads. Very important is the circumstance that in each foot the middle toe was symmetrical in itself, and decidedly larger than those on either side. The toes—and more especially those in the fore-foot—were distinctly expanded at the extremity, and during life were encased in horny sheaths which were probably more like hoofs than claws. Not less important is it to notice that in the skull the socket of the eye was not closed behind by a bar of bone, and was thus continuous with the great hollow on the sides of the temples for the reception of the muscles which worked the jaw. As regards the teeth, it must suffice to say, firstly, that they were forty-four in number, as in so many of the early generalized mammals, and that although well-marked tusks, or canines, were present in both jaws, there was no distinct gap at the commencement of the grinding, or cheek-series. Secondly, these cheek-teeth had very short crowns, surmounted by four simple conical elevations, or cusps, between which were a couple of smaller cusps. Into other details of the structure of this primitive creature it would be out of place to enter here. As to its coloration in life, no one has, I believe, hitherto ventured to make even a suggestion.

When, however, we advance one step further in the scale, and come to the *Hyracotherium* of the London Clay division of the Eocene, American palæontologists have been bold enough to say that the creature had a transversely striped coat comparable to that of the modern zebras; the reason for this being that all members of the horse tribe display, especially in the case of hybrids, a tendency to throw back, or revert, to a striped type of coloration. Whether we are justified in believing this ancestral striping to date so far back as the *Hyracotherium*, it is not for me to say.

As regards its organization, *Hyracotherium* differed markedly in many respects from the earlier *Phenacodus*, this being most clearly displayed in the skeleton of the feet (Fig. 2). The fore-foot had, for instance, become unsymmetrical, owing to the loss of the first, or "great," toe; the outermost of the four remaining digits being quite small, and having no fellow; the foot being thus comparable to the fore-foot of a tapir. The hind-foot, on the contrary, although more reduced, still retained the symmetrical form of the ancestral type, having lost both the first and the third digit, and thus being three-toed, like the corresponding foot of a tapir. *Hyracotherium*, which was no larger than a fox, still resembled its ancestor in having two bones to the second segment of each limb, that is to say a radius and ulna in the fore, and a tibia and fibula in the hind limb. Here it should be mentioned that between *Hyracotherium* and *Phenacodus* there may have existed an intermediate type with four toes to each foot. As regards its cheek-teeth, the creature presented a distinct

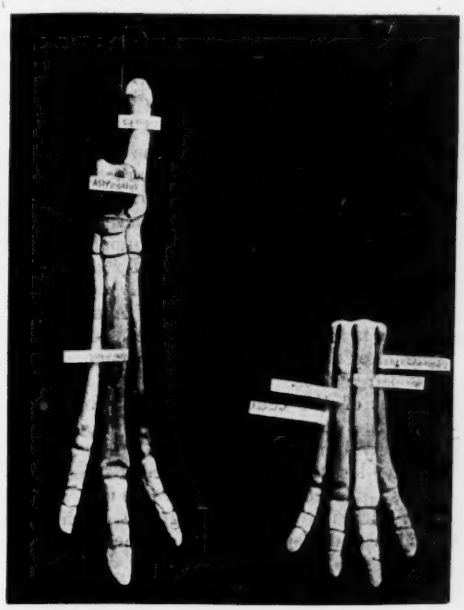


FIG. 2.—Bones of Left Hind and Fore Feet of *Hyracotherium*.

advance on *Phenacodus*. In the latter, as already said, the crowns of these teeth were surmounted by simple tubercles. On the other hand, in the former, three of these cusps in the upper teeth tend to unite to form an oblique anterior transverse ridge, while the three hinder ones tend to make a second posterior ridge; at the same time the two outer tubercles show indications of uniting so as to form a continuous outer wall to this part of the crown of

the tooth; this pattern being a forerunner of that obtaining in the cheek-teeth of the horse. The long tail of *Hyracotherium* was probably whip-like. Remains of the genus in question occur in the Lower Tertiary of North America as well as in that of Europe. In somewhat later deposits in both continents occur remains of more or less closely allied mammals known as *Pachynolophus*, which may or may not be in the direct horse ancestry. Later still, the well-known Palæotheria of the Oligocene strata of France and England, some of the species of which

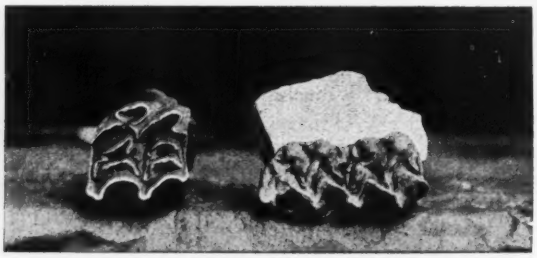


FIG. 3.—Crown Surfaces of a Right Upper Cheek-tooth of *Equus* and of Two Right Upper Cheek-teeth of *Anchitherium*.

were considerably larger than a tapir, were certainly off the main line of descent, their structure approximating more to that of the tapir type. When, however, we reach the Miocene Tertiary of both hemispheres we come upon remains of mammals which, although closely resembling the palæotheria in dental structure, yet exhibit unmistakable signs of nearer affinity with the horse. In Europe these creatures are known as *Anchitherium*, but some of the American forms are separated generically as *Miohippus*, one of the points of distinction being that whereas the front, or incisor, teeth of the latter are of a perfectly simple structure, those of the former begin to exhibit a slight infolding of the summit of the crown, thus foreshadowing the deep pit, or "mark," characterising those of the horse. The cheek-teeth of *Anchitherium* (Fig. 3), though still low-crowned, have acquired fully-developed transverse crests, and a continuous outer wall. Numerically the teeth agree with those of *Hyracotherium* and *Phenacodus*, but a difference is to be found in the relatively small size of the first pair of cheek-teeth in each jaw. A marked advance on the former is displayed in the fore-foot, which by the loss of the outer digit has once more become symmetrical, with only three toes. In both limbs the cannon-bone and toe-bones of the central digit have become greatly enlarged at the expense of the lateral digits, which are proportionately diminished, and there is a marked increase in the relative lengths of all the bones of the lower portion of the limbs. Moreover, it is noticeable that although the radius and ulna in the second segment of the fore-limb, and the tibia and fibula in that of the hind one remain distinct from one another, yet the ulna and fibula have become relatively more slender than in the earlier forms, and are in places more or less welded respectively to the radius and the tibia. In the matter of bodily size an important advance has also been established, one of the European species of *Anchitherium* being approximately of the dimensions of a tapir. In one of the American species of the closely allied genus *Mesohippus* a remnant of the upper end of the metacarpal, or uppermost bone, of the outermost, or fifth, toe still persists.

The next advance in this wonderful evolutionary chain is presented by the members of the genus *Protohippus*, of the Upper Miocene formation. These animals were essentially horses, although retaining the three toes of the ancestral *Anchitherium*. The skull, for instance, had become relatively large and elongated, with the socket of the eye separated from the temporal pit behind by a bony bar, and thus enclosed by a complete ring of bone. The front, or incisor teeth, were separated by an interval from the tusks, or canines, which were relatively short, and divided by another gap from the teeth of the cheek-series. Moreover, the summits of the incisors were pushed in, like the inturned fingers of a glove, thus giving rise to a distinct "mark" when half-worn. As regards the cheek-teeth, those of the first, or "milk" series, were curiously like the permanent set in the *Anchitherium*. The second, or persistent series, on the other hand, had acquired tall and squared crowns, which only developed roots when the animal was fully adult. In the pattern on the crown these teeth closely resembled those of the modern horse, with the exception of certain details which need not be noticed here; such pattern being the result of an excessive elevation of the simple crests of the *Anchitherium* molar, coupled with the pushing-in of certain portions, and the filling-up of the resulting hollows by the substance known as "cement," which is altogether lacking in the former. Then again, the first cheek-tooth in each jaw had become small and rudimentary. In the feet the lateral toes, although complete, had become relatively small, and scarcely, if at all, reached the ground, being in fact analogous to the rudimentary lateral toes of the ruminants. On the other hand, the central toe in each foot, with its supporting cannon-bone, was proportionately enlarged, and had become the real support of the body; the animal, like the modern horse, apparently standing solely on the

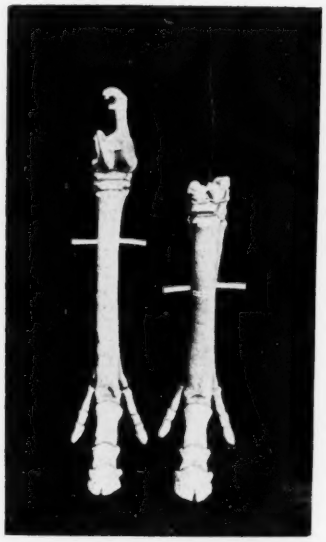


FIG. 4.—Skeleton of Left Hind and Fore Feet of *Protohippus*.

terminal joint of its middle toes. Higher up, the ulna in the fore-limb, and the fibula in the hind one, had become imperfect.

In the ordinary Pliocene three-toed horse, or *Hipparion*, of Europe and Asia, together with its North American representative, separated by some naturalists under the name of *Neohipparion*, the lateral toes were quite functionless, the ulna in the fore-limb had become fused with the radius, and the fibula in the hind-limb with the tibia, while the cheek-teeth had acquired somewhat taller and

more complicated crowns, and the gaps on each side of the canines were larger. Moreover, the small first cheek-tooth, or premolar, especially in the lower jaw, was quite rudimentary, and often shed in old age. There is, likewise, another point in connection with the cheek-teeth of this and the last genus. In *Anchitherium* and the earlier forms, the cheek-teeth, with their ridged crown-surface, were adapted solely for an up-and-down champing movement, such as occurs in the jaws of the pigs. On the other hand, the flat millstone-like surface formed by the cheek-teeth of the hipparion and the modern horse permits of a horizontal grinding movement, much better adapted to the comminution of hard substances. These three-toed horses were further peculiar for the presence of a depression on the sides of the face for a gland comparable to the tear-gland of deer and many antelopes; traces of the depression being visible in certain modern horse-skulls, and also existing in a much more marked degree in the extinct Siwalik horse (*Equus sivalensis*) of India.

The presence of these face-glands indicates that the hipparions probably frequented country covered with tall grass or bush, in which the scent given out by their secretion would aid the members of a troop in tracing the whereabouts of their fellows. On the other hand, in the open grassy plains (which by the way are probably a comparatively recent feature in the history of the earth) such aids are quite unnecessary, and the glands have accordingly been lost in the modern horse and its relatives. In height the hipparion stood about 4 feet 6 inches (13½ hands) at the shoulder. In coloration it was probably striped after the fashion of the zebras.

During the Pliocene period horses obtained for the first time an entry from the North into South America, where they developed into two generic types known as *Hippidium* and *Onohippidium*. Having large face-glands, and comparatively short and simple cheek-teeth, these South American horses were specially distinguished by the great length of the slit on each side of the face below the nose-bones. Evidently, therefore, they were off the line of the modern horse, although it is believed that the second, at any rate, were single-toed. If, as some believe, indigenous horses existed in South America at the time of its discovery, they must have been *Onohippidiums*.

In the Lower Pliocene of India and the Upper Pliocene of Europe and Asia appear for the first time true horses of the genus *Equus*, characterized by the total disappearance of external lateral digits, the sole relics of which are the splint-bones at the upper ends of the cannon-bones, alluded to above as being the only superfluous and apparently useless structures noticeable in the skeleton of the horse. They seem, in fact, to be structures of which these animals have been unable to rid themselves; and are actually injurious, being the cause of the disease known as splint. To the evolutionist they are, however, indescribably valuable, as affording incontrovertible evidence of the descent of the horse from the three-toed forms. In all the one-toed horses the pattern on the crowns of the upper cheek-teeth (Fig. 3) differs in a certain detail from that of the hipparions. The Pliocene horses approximate, however, in this respect more to the latter than in the case with their modern descendants, as they also do in the somewhat shorter crowns of the cheek-teeth. Moreover, the occurrence of a first upper premolar (the "wolf-tooth" of the vets.) was less uncommon in these Pliocene species than in the horses of to-day; and they occasionally developed the corresponding lower tooth, which is quite unknown in the latter. Whether, however, the mares of the Pliocene horses resembled those of the present day in the absence of the canines, I am unable to say.

Passing on from certainty to conjecture, it is probable that at least some of these Pliocene horses were striped like the zebras. Species, however, such as the immediate ancestors of the modern *Equus caballus*—the domesticated horse of the present day and its wild or semi-wild relatives the dun-coloured ponies of Mongolia—the wild asses, and, in a less degree, the extinct South African quagga, which took to a life in the open plains in countries where there is strong sunlight, found this type of coloration unsuited to their needs and accordingly assumed a more or less uniformly coloured coat, as being best adapted for protective resemblance in such situations. The above-mentioned tendency to revert to stripes, especially in the case of hybrids, affords, however, proof of their zebra-like ancestry.

As early as the Prehistoric period, as we infer from the rude drawings of the animal by its first masters, the European horse was uniformly coloured—probably dun with dark mane, tail, and legs. It was a small heavy-headed brute, with rough scrubby mane and tail, and no trace in the skull of the depression for the face-gland. From this stock are descended the cart-horses and the ordinary breeds of Western Europe. The blood-horse, or thoroughbred, on the other hand, is a later importation into Europe either from Arabia, by way of Greece and Italy, or, as some think, from North Africa, the home of the barb. It has been supposed that these Eastern horses are the descendants of an earlier domestication of the same stock. I have, however, recently shown the existence in an Indian domesticated horse-skull, as well as in the skull of the race-horse "Ben d'Or," of a distinct trace of the depression for a face-gland, and the suggestion consequently presents itself that the Eastern horses (inclusive of thoroughbreds) are derived from *Equus sivalensis*, in which the face-gland may still have been functional. The thoroughbred, as contrasted with the cart-horse, exhibits the extreme limit of specialisation of which the equine stock is capable; this being displayed not only by the gracefulness and beauty of its bodily form and the relatively small size of its head and ears, but likewise by the greater relative length of the bones of the lower segments of the limbs as compared with the upper ones, namely, the humerus in the fore-limb, and the femur in the hind pair. In this respect, therefore, the blood-horse departs the furthest of all the tribe from its tapir-like ancestors, as it does in its height at the shoulder.

But it is not only in its skeleton that the horse exhibits traces of its affinity with its predecessors. On the hinder part of the foot a little above the hoof is a structure known to veterinarians as the "ergot." This, which apparently attains its greatest development in Grévy's zebra of Somaliland, corresponds with one of the foot-pads of the tapir, and points to a time when the ancestral horses applied the under surface of the fetlock to the ground. More remarkable still are the callosities, "chestnuts," or "castors," found on the inner sides of both limbs in the horse (inclusive of the Mongolian wild ponies), but only on the fore-legs of the other species, which are likewise rudimentary, or vestigial structures. Although it has been suggested that these also represent foot-pads (with which they by no means agree in position), it is far more probable that they are really remnants of glands (similar to those found in somewhat the same situation in the hind-limbs of many deer and the front ones of many antelopes), and that their disappearance as functional organs was approximately coincident with that of the loss of the face-glands of the hipparions, owing to both being no longer required. Even now, it is said, these callosities, when freshly cut, exude a humour the smell of which will cause a horse to follow for almost any distance.

XUM

MICROSCOPY

Conducted by F. SHILLINGTON SCALES, F.R.M.S.

MICROSCOPICAL RESOLUTION.

For the meeting of the Royal Microscopical Society on the 19th November, a paper had been announced by Prof. Everett, F.R.S., dealing with "Microscopical Resolution." Those interested in the theory of the microscope who attended in the hope of increasing their knowledge of this aspect of the subject were doomed to be disappointed as far as this paper was concerned, for the learned author had evidently misapprehended the scope of Equation 32 of Lord Rayleigh's paper on "The Theory of Optical Images," recently reprinted in the R.M.S. Journal. The elementary formula which Prof. Everett deduced in the usual elementary way for the difference of phase between adjoining slits of a grating—and which Lord Rayleigh gives as No. 45—is quite correct, and leads, when discussed in a similarly elementary manner, to the familiar diffraction spectra, but without disclosing the not entirely unimportant intermediate secondary maxima. But Lord Rayleigh's paper goes far beyond this; it determines the *distribution of light in the final image* of a grating, with only these two simplifying assumptions: that the number of lines is infinite, and that the lines are negligibly narrow compared to the dark intervals.

The theorists were, however, fortunate in hearing an exposition from Dr. Johnstone Stoney, F.R.S.—a rare visitor—who was asked to speak.

Having pointed out that the familiar but elusive "rays" of light can be used only for elementary purposes, and must be supplanted by "waves" in all thorough investigations, and having alluded to his method of resolving undulations into plane wavelets, Dr. Stoney proceeded to communicate some extremely interesting results of his experiments with gratings.

He first showed how *two* lines a certain distance apart could be resolved by an aperture quite incapable of resolving a greater number of lines at similar distances. But whilst the lines are properly resolved—that is, separated by a dark interval—their distance apart is, in these circumstances, misrepresented. They appear too far apart in inverse proportion to the distance apart of the portions of two diffused diffraction fringes utilized. This is an experimental proof of the correctness of the reasoning leading to the Abbe theory, which is as novel as it is important.

His next point was equally interesting and valuable. When the number of lines in a grating is finite, and particularly when it is *small*, the complete diffraction spectrum produced by the grating is not limited to the familiar principal maxima; there are (n-2)—n being the number of lines in the grating—secondary maxima between every two principal ones, and those of these secondary maxima which are near a principal maximum are of appreciable brightness. Dr. Stoney has been able to demonstrate that these secondary maxima, when combined with the direct light, *the first diffraction-spectrum itself being excluded by reducing the aperture of the microscope*, are capable of giving a feeble kind of resolution. And, as in the previous case, there is again complete agreement between the results of the direct experiment and that to be expected theoretically, for the faint image secured in this way shows the exact defects and peculiarities which theory demands.

Dr. Stoney's third point also proved of interest. Perhaps the greatest defect of the published accounts of the Abbe theory lies in the utter want of definite information of a practical kind. It is stated that there can be no *complete* similarity between object and image unless every diffraction spectrum of appreciable intensity is utilised, and apparently with a view to impressing the confiding microscopist with the importance of this doctrine, certain experiments with the "Diffractions-platte" are mentioned which yield a dissimilarity between object and image that is absolutely startling. Of course, this is right when *complete* similarity is taken in its strictest sense, *i.e.*, down to the minutest detail, which, however, no practical man would expect to see under any conditions. What the latter desires to know is *how much* dissimilarity he must be prepared for, and to the practical man Dr. Stoney's testimony as to the remarkable improvement of microscopical images when the second spectrum is admitted must, therefore, be a welcome guide.

Dr. Stoney proceeded to make some further remarks on the importance of Condenser-adjustment in attempting very delicate resolving tests, but his interesting communication had to be terminated with a view to securing the remaining portion of the evening for another paper on the agenda.

Very few microscopists are really competent to appreciate the value of microscopical theory, and the high importance of taking every advantage that can be suggested for accurate manipulation. It is to be hoped, therefore, that Dr. Stoney's suggestions may, in due course, appear in print, and thus afford an opportunity to intelligent and thoughtful workers to assess them at their proper value. Dr. Stoney's remarks were not only of interest but to the point, for microscopical resolution was the subject which was opened by the somewhat disappointing paper which had brought our veteran physicist to this meeting.

QUEKETT MICROSCOPICAL CLUB.—The 408th ordinary meeting was held on November 20th, at 20, Hanover Square, W., the Vice-President, J. G. Waller, Esq., F.S.A., in the chair. There was as usual a large attendance of members and visitors. Mr. W. H. Langton exhibited a small portable microscope, which he had constructed without the use of a lathe. It was fitted with sliding coarse adjustment, two-speed fine adjustment, and motions to stage, substage and mirror. The various adjustable parts were kept in alignment with the body of the instrument by means of grooves in the ring fittings, the grooved rings travelling on a steel wire fixed in alignment with the body tube. Mr. Langton was complimented by many members on the ingenuity displayed in the construction of the instrument.

Mr. W. Wesché gave a demonstration, illustrated by the lantern, of the homology of the mouth parts of Dipterous flies with the mouth of the cockroach. It was shown how the mandibles were fused into the upper part of the proboscis of the blow-fly, and the maxillæ, or inner jaws, embedded in the base. Mr. Wesché also exhibited a number of minute palpi discovered by himself in many different species of Diptera.

Mr. L. R. Gleason gave an address on bacteriology as considered from the point of view of the amateur. It was illustrated by lantern slides of cultures and apparatus, and by specimens under the microscope. He wished to correct the popular idea that very high powers and expensive apparatus were a *sine quâ non* for bacteriological work. A great deal could be done with a $\frac{1}{8}$th-inch objective and a little ingenuity in the preparation of apparatus. He would not, of course, recommend the amateur to undertake the culture of pathogenic germs, but the non-pathogenic germs were quite as interesting to study, and, moreover, were in many cases of the highest value to man. Linen, hemp, tobacco, opium, butter, cream, cheese, and a host of other domestic products were produced by the action of these invisible workers, and he trusted that many microscopists in search of a field for study would turn their efforts in this direction.

"JOURNAL OF THE QUEKETT MICROSCOPICAL CLUB."—The half-yearly number of this journal has just reached me, and contains several interesting and useful papers, amongst which I may mention Messrs. Marks and Wesché's "Further Observations on Male Rotifers," and a second part of Mr. D. J. Scourfield's "Synopsis of the well-known species of British Freshwater Entomostraca," dealing with the Copepoda. Mr. R. T. Lewis contributes a note on a hitherto undescribed species of *Chelifer*, illustrated by a plate; and Mr. D. Bryce has a note on two new species of *Philodina*. Among the more popular articles may be mentioned Mr. W. H. Harris' "Remarks on the Emission of Musical Notes, and on the Hovering Habit of *Eristalis tenax*"; and amongst practical notes one by Mr. H. J.

Quilter on "A Method of taking Internal Casts of Foraminifera," which should prove useful to students, and might be capable of extended application.

WATSON'S "ARGUS" MICROSCOPE.—A cheap microscope may generally be looked upon with suspicion, but Messrs. W. Watson & Sons have just brought out a new microscope, which is not only cheap but of excellent workmanship. The design has several novel features. The limb is rigidly attached to the stage, as in all Messrs. Watson's models, but the fine adjustment is of the direct-acting micrometer screw type, actuated by an inverted head placed beneath the limb. The coarse adjustment is by means of a diagonally cut pinion which engages directly in the threads of the screw of this fine adjustment, there being another supporting wheel on the other side, so that one slide serves both for coarse and fine adjustment. The foot is of the tripod pattern with a spread of nearly 7 inches; the body is inclinable; the stage is 3½ inches square; and the body is provided with a draw-tube giving a variable tube-length of from 5½ to 9 inches. The eyepieces are the R.M.S. standard Continental size, *i.e.*, ·9173 inch. There are adjustable double mirrors, and a ring beneath the stage of the R.M.S. standard gauge, for condenser, &c. Compensating screws are provided for the working parts of the microscope. For this particular microscope Messrs. Watson have introduced a new series of objectives at specially low prices; but of these I shall have more to say when I have had an opportunity of examining them personally.

NEW METHOD OF MOUNTING ROTIFERS.—I have recently seen some Rotifers mounted by a method which appears to me to have several novel points. The Rotifers, which were of the genus *Megalotrocha*, are now more than two years old, but are as bright and clear as when first mounted. They were put up by Mr. W. Brockett, Laboratory Assistant in the Zoological Laboratories at Cambridge, and I am indebted to him for the following explanation of his method. A few living Rotifers are put in a large drop of water on an ordinary slide. They are then narcotised by the addition to the water of a very few granules of cocaine. When perfectly extended, after examination under a lens or a microscope, a drop of two per cent. osmic acid is placed on a clean cover-glass, which is then rapidly inverted and as quickly lowered on to the Rotifers. Actual contact, and therefore compression of the animals, is prevented by small pieces of gum label being stuck on the slip at each corner of the cover-glass, so as to make four small supports. The osmic acid is allowed to remain from one to three minutes, the progress of the staining being carefully watched under the microscope, after which distilled water is run under the cover-glass by the "irrigation" method. This is merely the placing of a small quantity of the irrigating fluid at one side of the cover-glass and applying a piece of blotting paper to the opposite side, by which means a current is set up and the fluid drawn under the cover-glass. By the same method of irrigation, picro-carmine is then also drawn under, and allowed to stain for ten to thirty minutes, the progress of the staining being carefully watched as before. Finally, by the same method, there must be gradual dehydration with 30 per cent., 50 per cent., 70 per cent., and 90 per cent. alcohols in the order given, after which follows clearing with the usual clearing agents, and mounting (still by the same method of irrigation) with balsam dissolved in absolute alcohol. The slides will then appear of a milky opacity, and be apparently useless, but should be put aside for twenty-four hours, when they will become clear and limpid. This clearing-up can be hastened by the application of moderate heat, but the risks are manifold. It will be noticed that an essential part of this method is the non-disturbance of the Rotifers from the time they were narcotised, and the drawing between cover-glass and slip, of all the staining and dehydrating re-agents, and of the mounting medium, by the method of irrigation.

MICROSCOPICAL MATERIAL.—By the kindness of Mr. C. S. Poulter, of Wallington, I am able to offer to the microscopical readers of KNOWLEDGE some leaves of *Deutzia scabra*, showing stellate hairs, and of *Elaeagnus edulis*, showing peculiar scales. Those who desire to avail themselves of this material, should send me a stamped addressed envelope, together with the coupon appearing in the advertisement columns of this journal.

NOTES AND QUERIES.

C. Judson.—There is no reason why the numerical aperture of substage condensers as well as of objectives should not be determined by the method described in KNOWLEDGE of November last. It should be borne in mind, however, that the essential value of a condenser lies less in its total aperture than in the aplanatic cone which it is capable of transmitting, namely, in that portion of its cone of light which is properly corrected. Thus the Abbe form of chromatic condenser with a numerical aperture of 1·2 or 1·4 N.A. has an aplanatic aperture of not more than ·5, whilst the recent English achromatic condensers of 1 N.A. have aplanatic apertures varying from ·9 to ·95 N.A., and immersion condensers of 1·4 N.A. may have aplanatic apertures as high as 1·3 N.A. An objective is a complicated combination of lenses, so that the rules by which the focal length of a single lens may be determined do not apply to it, but what you probably require is not the focal length so much as the approximate equivalent focus, or, more definitely, the initial magnification. I hope to have a note dealing with these matters in the next issue of this Journal.

Power of Locomotion in Lophopus crystallinus.—Mr. Willoughby Dade, of 13, Northbrook Road, Dublin, writes:—"There seems to be a division of opinion as to whether *Lophopus crystallinus* has power of locomotion or not. Indeed, most authorities say it has not. I have been keeping some colonies in a ten-inch bell-jar for some time, and am confident that they have this power. A short time since a group of about twenty individuals divided, and three or four days later the two colonies were fully a third of an inch apart, and now they are on different branches of a piece of milfoil. I find all the fresh-water Polyzoa in the Royal Canal here, excepting *Alcyonella*, which Allman says does not inhabit Ireland. *Lophopus* does very well in confinement, *Cristatella* only fairly well, but I am not successful with the tubed genera such as *Plumatello repens*, *Paludicella*, and *Fredericella*. These do not thrive, partly, I fancy, because *Cyclops* appears to be fond of picking the polypides out. I should be very glad to know with what success other pond-hunters keep these animals in captivity."

L. B.—It is exceedingly difficult to indicate the subjects, which would be likely to prove most interesting to you, in which the microscope could be used. There is so large a range, and every department dealt with intelligently provides such varied and interesting material for study and observation, that a knowledge of personal tastes and inclinations would be desirable before recommending. In the "Knowledge Diary" for 1904, obtainable from the publishers of this Journal, is an article entitled "Some Uses of the Microscope," which might prove of interest to you. It might be that on reflection you would prefer some other instrument, such as a telescope, in which case you would find the Diary referred to exceedingly valuable, for it contains: "The Heavens for 1904," "An Astronomical Summary," "Practical Work of a Small Telescope," and other scientific information.

T. Webster.—The publisher of KNOWLEDGE, to whom I have handed your letter, will be able to inform you of a likely place to obtain a table similar to that described by Mr. Morgan. The description and illustration were intended to aid those who were interested in getting such a device constructed locally, but so many readers have enquired for a source of supply that the publisher has taken the matter in hand.

J. J. Macdonald.—It would be impossible to give any explicit direction as to the size of stop required to produce a black background without knowing the condenser and objective that were to be employed, together with the numerical apertures of both. It is likely that you are attempting to obtain a black background with an objective possessing too large an N.A. Except the aperture of the objective be cut down, it is not convenient to obtain black ground illumination with numerical apertures in excess of ·75.

Communications and enquiries on Microscopical matters are cordially invited, and should be addressed to F. SHILLINGTON SCALES, "*Jersey*," *St. Barnabas Road, Cambridge.*

XUM

BOTANICAL NOTES.—It is probable that the legend respecting the origin of the Glastonbury Thorn is well known. How Joseph of Arimathea, in visiting Britain on a preaching mission, arrived weary at Glastonbury, and while he rested, his hawthorn walking stick was thrust into the ground. How it at once began to grow, and ever after, so the legend says, flowered on Christmas Day. The thorn is simply *Cratægus Oxyacantha præcox*, an early flowering variety of our common hawthorn. That it does flower remarkably early is quite true, for a tree in the Royal Botanic Gardens, Kew, opens its flowers between November and March. This year it is now (early in December) bearing advanced flower-buds, which, had not the frosts injured them, would have expanded at Christmas time.

Another part of "Hooker's Icones Plantarum" has just been issued, and this contains descriptions and figures of several especially noteworthy plants. *Aniba megacarpa*, seen in the fruiting stage only, might easily be mistaken for an oak (*Quercus*), in which is found such remarkable variations in the cupules and acorns. This *Aniba* has a large, much-thickened cupule, and an oblong nut about three inches long. The genus belongs to the Laurineæ. Rubber plants, to which an extensive literature is now devoted, are met with in this part of the "Icones" in two species of *Landolphia* and one of *Sapium*. *Landolphia Kirkii* is a very important plant, commercially. In an interesting note on the manner of collecting the rubber, we are informed that it "is collected in a way that is perhaps unique in any rubber-yielding plant. Some of the milk from a wound is allowed to coagulate. The pellet so obtained is applied to a fresh cut, and being turned with a rotary motion, the exuding milk is drawn off like silk from a cocoon. It is said that by working hard one person can collect five pounds of rubber *per diem*." In the other species of *Landolphia* figured, the rubber has to be coagulated by heat. Both are natives of Tropical Africa. —S. A. S.

THE FACE OF THE SKY FOR JANUARY.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the sun rises at 8.8 and sets at 3.59; on the 31st he rises at 7.44 and sets at 4.43.

Sunspots may now frequently be observed.

The earth is at its least distance from the sun on the 3rd; the sun has then its maximum apparent diameter of 32′ 35″·2.

THE MOON:—

	Phases.	H. M.
Jan. 3	○ Full Moon	5 47 A.M.
„ 9	☾ Last Quarter	9 10 P.M.
„ 17	● New Moon	3 47 P.M.
„ 25	☽ First Quarter	8 41 P.M.

The moon is in perigee on the 4th, and in apogee on the 19th.

OCCULTATIONS.—The particulars of the occultations of the brighter stars during the month are as follow:—

Date.	Star Name.	Magnitude.	Disappearance. Mean Time.	Disappearance. Angle from N. Point.	Disappearance. Angle from Vertex.	Reappearance. Mean Time.	Reappearance. Angle from N. Point.	Reappearance. Angle from Vertex.	Moon's Age.
			h. m.	°	°	h. m.	°	°	d. h
Jan. 1	111 Tauri	5·2	6 8 P.M.	129	170	6 49 P.M.	214	253	13 21
„ 3	26 Geminorum	5·1	1 34 A.M.	66	46	2 32 A.M.	308	274	15 4
„ 5	o Leonis	3·8	10 13 P.M.	129	167	11 9 P.M.	259	295	18 1
„ 26	O.M. +12°436	5·9	7 19 P.M.	25	16	8 11 P.M.	302	281	9 4
„ 28	B.A.C. 1526	5·8	6 16 P.M.	70	99	7 28 P.M.	271	286	11 3
„ 30	λ Geminorum	3·6	3 6 A.M.	106	66	4 3 A.M.	275	234	12 11

THE PLANETS.—Mercury is an evening star in Capricornus. He is at greatest easterly elongation on the 1st, being 19′·30 E., and sets for a few days near this time about 1½ hours after the sun. On account of his great southerly declination, however, he is not favourably situated for easy observation. He is again in inferior conjunction with the sun on the 17th.

Venus is a morning star, and rises on the 1st at 4.22 A.M., and on the 31st at 5.28 A.M. Her brilliance, is, however, diminishing on account of increasing distance from the earth and greater southerly declination.

Mars is low down in the south-west at sun-set, but is very feeble and badly placed for observation.

Jupiter is on the meridian about sunset near the beginning of the month, whilst near the end of the month he sets about 9 P.M.

The diameter of the planet is diminishing on account of his increasing distance from the earth, the polar and equatorial diameters being 34″·3 and 36″·7.

The configurations of the satellites, as seen in an inverting telescope, and observing at 7 P.M., are as follow:—

Day.	West.	East.	Day.	West.	East.
1	3 2 ○ 1 4		17	3 ○ 1 2 4	
2	3 1 ○ 2 4		18	2 ○ 3 4 ●	
3	1 ○ 2 4 ●		19	2 1 ○ 3 4	
4	2 ○ 1 4 3		20	○ 1 2 3 4	
5	½ ○ 4 3		21	1 3 ○ 2 4	
6	4 ○ ¾ 2		22	3 2 ○ 4 1	
7	4 3 1 ○ 2		23	3 4 1 2 ○	
8	4 3 2 ○ 1		24	4 3 ○ 1 2	
9	4 3 1 ○ 2		25	4 2 1 ○ 3	
10	4 ⊙ 2 ●		26	4 2 ⊙ 3	
11	4 2 ○ 3 ●		27	4 ○ 1 2 3	
12	4 2 1 ○ 3		28	4 1 ⊙ 2	
13	4 ○ 1 3 2		29	4 3 2 ○ 1	
14	¾ ○ ½		30	3 ¼ 2 ○	
15	3 2 ○ 1 4		31	3 ○ ¼ 2	
16	3 1 ○ 4 ●				

The circle (○) represents Jupiter; ⊙ signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc, or in the shadow. The numbers are the numbers of the satellites.

Saturn and Uranus are lost in the sun's rays and cannot be observed.

Neptune comes to the meridian about 10.30 P.M., near the middle of the month; being close to μ Geminorum, he can readily be found by reference to that star, their respective positions on the 16th being:—

	Right Ascension.	N. Declination.
Neptune ...	6h. 17m. 16s. ...	22° 18′ 31″
μ Geminorum ...	6h. 17m. 11s. ...	22° 33′ 37″

The planet therefore will be 15′ directly south of the

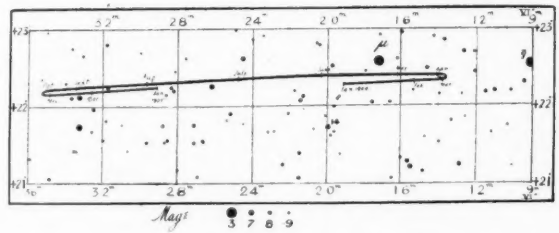


Chart showing path of Neptune in 1904.

star, and will appear in the same field of view with a not too high power eyepiece. The above chart shows the planet's path during the year 1904.

METEOR SHOWERS:—

Date.	Radiant. R.A.	Radiant. Dec.	Name.	Characteristics.
	°	°		
Jan. 2-3	230	+53	Quadrantids	Swift; long paths
„ 17	295	+53	κ Cygnids	Slow; bright

THE STARS.—The positions of the principal constellations near the middle of the month at 9 P.M. are as follow:—

ZENITH . Perseus, Auriga (*Capella*).

SOUTH . Pleiades, Taurus, Orion, with Aries and Cetus towards the S.W., and *Procyon* and *Sirius* towards the S.E.

WEST . Pegasus, Andromeda, Aquarius and Pisces; Cygnus to the N.W.

EAST . Leo (*Regulus*) low down, Cancer, Gemini (*Castor* and *Pollux*) high up.

NORTH . Ursa Minor and Draco below *Polaris*, with Cassiopeia to the left and Ursa Major to the right.

Minima of Algol may be observed on the 10th at 1.21 A.M., 12th at 10.9 P.M., and on the 15th at 6.58 P.M.

TELESCOPIC OBJECTS.—Nebulæ.— Orion Nebula, situated in the sword of Orion, and surrounding the multiple star θ, is the finest of all nebulæ, and is so bright that it can be discerned with the naked eye; with a 3 or 4-inch telescope, it is best observed when low powers are employed.

Crab Nebula (M 1), in Taurus, situated about $1\frac{1}{2}°$ north-west of ζ Tauri in R.A. 5h. 29m., Dec. 21° 58′ N.

Clusters.—M 37, situated in Auriga, is one of the finest clusters, and very compact; its position is R.A. 5h. 46m., Dec. 32° 32′ N.

DOUBLE STARS.—β Orionis (Rigel), mags. 1 and 9, separation 9″. On account of the brightness of the principal star, this double is a fair test for a good object-glass of about 3-inch aperture.

δ Orionis, mags. 2 and 7, separation 53″; easy double.

ζ Orionis, triple, mags. 3, 6, and 10, separation 2″·5 and 56″; rather difficult in a 3-inch telescope.

λ Orionis, mags. 4 and 6, separation 4″·5; pretty double.

σ Orionis, triple, mags. 4, 8 and 7, separation 12″·5 and 42″. There are several other small stars near, and the

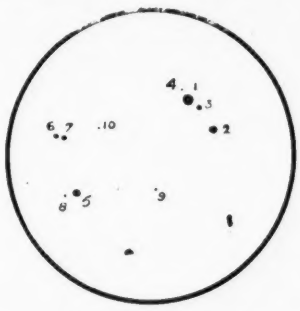


Diagram of σ Orionis.

detection of the fainter ones is looked upon as a good test of the light-gathering power of the telescope. With a 3-inch, one can see up to number 7, though 4 is very difficult.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. LOCOCK, KNOWLEDGE Office, 326, High Holborn, and be posted by the 10th of each month.

Solutions of December Problems.

No. 1 (W. Geary).

Key-move.—1. B to B7.

If 1. . . . K to B5, 2. Q to KBsq, ch.
1. . . . Kt (Bsq) moves, 2. B × Kt.
1. . . . P to R6, 2. Q to Q3ch.
1. . . . P to Q5, 2. Q to Ksq, ch.
1. . . . P to Kt5, 2. Q to Q4ch.
1. . . . Kt (Q3) moves, 2. Q to Q3 mate.

No. 2 (C. D. Locock).

Key-move.—1. Kt to R8.

If 1. . . . K to B4, 2. Q to R7.
1. . . . K to K6, or Kt6, 2. Q × Pch.

SOLUTIONS received from "Alpha," 4, 4; W. Nash, 4, 4; G. A. Forde (Major), 4, 4; "Looker-on," 4, 3; G. W. Middleton, 4, 4; "Quidam," 4, 4; J. W. Dixon, 4, 4; C. Johnston, 4, 4; H. S. Brandreth, 4, 0; H. F. Culmer, 4, 4; T. Dale, 4, 4; J. Jones (Salford), 4, 4.

"*Looker-on.*"—After 1. Kt to B8 (which you give as an alternative to 1. Kt to R8), the defence K to B4 appears to be good; for if then 2. Q to R7, K × P. Many condolences on the loss of a point at the last and critical moment.

H. S. Brandreth.—After 1. B to Q5, K to B4; 2. Q to Bsq., K to Kt3. There is no mate.

C. Johnston.—Many congratulations. Please send your full address.

RESULT OF SOLUTION TOURNEY, 1903.

Winner of the KNOWLEDGE Challenge Trophy.—C. Johnston, 83.

Winner of Second Prize (15s.).—"Looker-on" (G. J. Slater, Bolton), 82.

Winner of Third Prize (KNOWLEDGE for 12 months).—J. W. Dixon, 81.

These are closely followed by W. Nash and "Quidam," 80. Other scores worthy of mention being: G. W. Middleton, 73; "Alpha," 68; H. F. Culmer, 64; G. A. Forde (Major), 62; and T. Dale, 58. Mr. Dale did not compete during the first three months, or he would evidently have taken a much higher place.

The above award will remain open for one month.

The scores of the first five show the closeness of the competition, the result of which was in doubt till the last. Last year Mr. "W. Jay" came out with a clear lead of four points. In the present competition the holder of the trophy retired early, and Mr. C. Johnston, who tied for fourth place last year—20 points behind Mr. Jay—scores a well-deserved success and becomes the second holder of the Challenge Trophy, "Looker-on" (Mr. G. J. Slater, the well-known composer) once more taking the second place. Mr. Dixon, winner of the third prize, did not compete last year. The same applies to "Quidam"; Mr. W. Nash is a place lower.

XUM

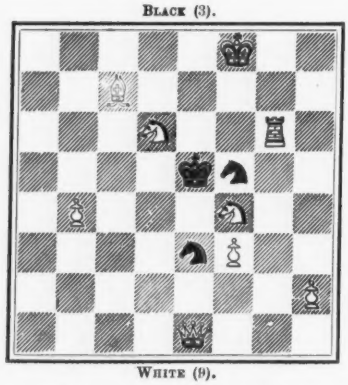
While sympathizing with "Looker-on" on his bad luck, the Chess Editor, who fully realized the difficulty of deciding what looked like a probable tie between two expert solvers, may perhaps be pardoned for congratulating himself on having effected a separation just in time to prevent the tie, by means of a problem specially composed for the occasion. He hopes that all last year's competitors, and many others, will take part in the new Solution Tourney which begins with the problems in the present number.

PROBLEMS.

No. 1.

By A. H. Human.

BLACK (3).



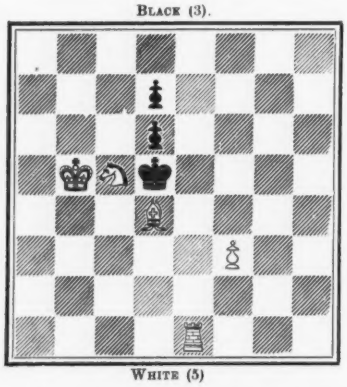
WHITE (9).

White mates in two moves.

No. 2.

By J. C. Candy.

BLACK (3).



WHITE (5)

White mates in three moves.

SOLUTION TOURNEY, 1904.

This year's Solution Tourney commences in the present number of KNOWLEDGE, and will continue till the end of the year. The winner will hold for twelve months the KNOWLEDGE Challenge Trophy. This will become the property of any solver who wins it three years in succession, or four years altogether. In the event of a tie between the previous holder and another, the holder will retain possession of the trophy; in that case, however, neither a win nor a loss will be scored to the holder. Should others than the holder tie for first place, the tie must be decided as below.

The second prize will be 15s., and the third prize KNOWLEDGE for twelve months. In the event of ties for either or both of these, the ties shall be decided by a further trial of skill under new conditions, or the prizes divided at the discretion of the Chess Editor.

The problems published will be either three-move or two-move direct mates, and not more than two will appear in any number. In the event of any problem being incorrectly printed, it will be cancelled and reprinted. Points will be awarded as follows:—

Two-move Problems.—Any one correct key, **2** points; a *second* solution, **1** point.

Three-move Problems.—Any one correct key, **4** points; a *second* solution, **2** points.

One point will be deducted for any *one* incorrect claim for a second solution. A correct claim of "no solution" will count as a correct key.

SPECIAL NOTE.—Duals will not score. All solutions must bear postmark of the issuing office not later than the 10th of the month of publication.

CHESS INTELLIGENCE.

The proposed match between Messrs. Blackburne and Marshall has been abandoned. Mr. Marshall is an enterprising player who aims high; but matches between leading chess-players have always been notoriously difficult to arrange. Mr. Marshall has lately been annotating many of the games in the *British Chess Magazine*, in the place of Mr. James Mason, who has been incapacitated by ill-health. At the time of writing we learn with regret that Mr. Mason has had a serious relapse. All chess players will wish him a speedy recovery.

Surrey defeated Sussex on November 21st, after a very closely contested match, by $8\frac{1}{2}$ games to $7\frac{1}{2}$. The games on the four top boards were all drawn. Surrey lost on the next three boards, but their "tail" proved strong enough to outweigh this, and give them the victory.

All manuscripts should be addressed to the Editors of KNOWLEDGE, 326, High Holborn, London; they should be easily legible or typewritten. All diagrams or drawings intended for reproduction, should be made in a good black medium on white card. While happy to consider unsolicited contributions, which should be accompanied by a stamped and addressed envelope, the Editors cannot be responsible for the loss of any MS. submitted, or for delay in its return, although every care will be taken of those sent.

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For Contents of the Last Two Numbers of "Knowledge," see Advertisement pages.

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